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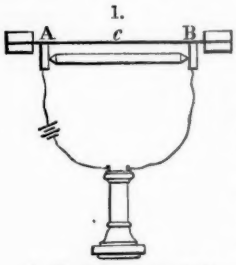
ART. XV.—*Upon a modification of Wheatstone's Microphone and its applicability to Radiophonic Researches;* by ALEXANDER GRAHAM BELL.

[A paper read before the Philosophical Society of Washington, D. C., June 11, 1881.]

IN August, 1880, I directed attention to the fact that thin disks or diaphragms of various materials become sonorous when exposed to the action of an intermittent beam of sunlight, and I stated my belief that the sounds were due to molecular disturbances produced in the substance composing the diaphragm.* Shortly afterwards Lord Raleigh undertook a mathematical investigation of the subject, and came to the conclusion that the audible effects were caused by the bending of the plates under unequal heating.† This explanation has recently been called in question by Mr. Preece,‡ who has expressed the opinion that although vibrations may be produced in the disks by the action of the intermittent beam, such vibrations are not the cause of the sonorous effects observed. According to him, the aerial disturbances that produce the sound arise spontaneously in the air itself by sudden expansion due to heat communicated from the diaphragm—every increase of heat giving rise to a fresh pulse of air. Mr. Preece was led to discard the theoretical explanation of Lord Raleigh on account of the failure of experiments undertaken to test the theory.

* American Association for the Advancement of Science, Aug. 27, 1880.
† Nature, vol. xxiii, p. 274. ‡ Roy. Soc., March 10, 1881.

He was thus forced—by the supposed insufficiency of the explanation—to seek in some other direction the cause of the phenomenon observed, and, as a consequence, he adopted the ingenious hypothesis alluded to above. But the experiments which had proved unsuccessful in the hands of Mr. Preece were perfectly successful when repeated in America under better conditions of experiment, and the supposed necessity for another hypothesis at once vanished. I have shown, in a recent paper read before the National Academy of Science,* that audible sounds result from the expansion and contraction of the material exposed to the beam; and that a real to-and-fro vibration of the diaphragm occurs capable of producing sonorous effects. It has occurred to me that Mr. Preece's failure to detect with a delicate microphone the sonorous vibrations that were so easily observed in our experiments might be explained upon the supposition that he had employed the ordinary form of Hughes's microphone shown in fig. 1, and that the vibrating area was confined to the central portion of the disk. Under such circumstances it might easily happen that both the supports (A, B,) of the microphone might touch portions of the diaphragm which were practically at rest. It would of course be interesting to ascertain whether any such localization of the vibration as that supposed really occurred, and I have great pleasure in showing to you to-night the apparatus by means of which this point has been investigated. (See fig. 2.)



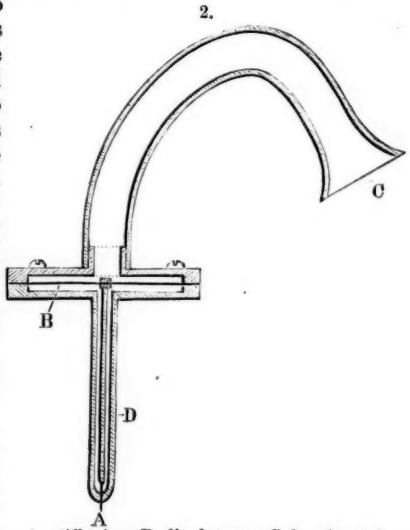
A, B, carbon supports; *c*, diaphragm.

The instrument is a modification of the form of microphone devised in 1827 by the late Sir Charles Wheatstone, and it consists essentially of a stiff wire (A), one end of which is rigidly attached to the center of a metallic diaphragm (B). In Wheatstone's original arrangement the diaphragm was placed directly against the ear, and the free extremity of the wire was rested against some sounding body—like a watch. In the present arrangement the diaphragm is clamped at the circumference like a telephone-diaphragm, and the sounds are conveyed to the ear through a rubber hearing tube (*c*). The wire passes through the perforated handle (D) and is exposed only at the extremity. When the point (A) was rested against the center of a diaphragm upon which was focussed an intermittent beam of sunlight, a clear musical tone was perceived by applying the ear to the hearing tube (C). The surface of the diaphragm was

* April 21, 1881.

then explored with the point of the microphone, and sounds were obtained in all parts of the illuminated area and in the corresponding area on the other side of the diaphragm. Outside of this area on both sides of the diaphragm the sounds became weaker and weaker, until at a certain distance from the center they could no longer be perceived.

At the points where one would naturally place the supports of a Hughes microphone (see fig. 1) no sound was observed. We were also unable to detect any audible effects when the point of the microphone was rested against the support to which the diaphragm was attached. The negative results obtained in Europe by Mr. Preece may therefore be reconciled with the positive results obtained in America by Mr. Tainter and myself. A still more curious demonstration of localization of vibration occurred in the case of a large metallic mass. An intermittent beam of sunlight was focussed upon a brass weight (1 kilogram), and the surface of the weight was then explored with the microphone shown in fig. 2. A feeble but distinct sound was heard upon touching the surface within the illuminated area and for a short distance outside, but not in other parts.



A, stiff wire; B, diaphragm; C, hearing tube; D, perforated handle. Figure reduced one-half.

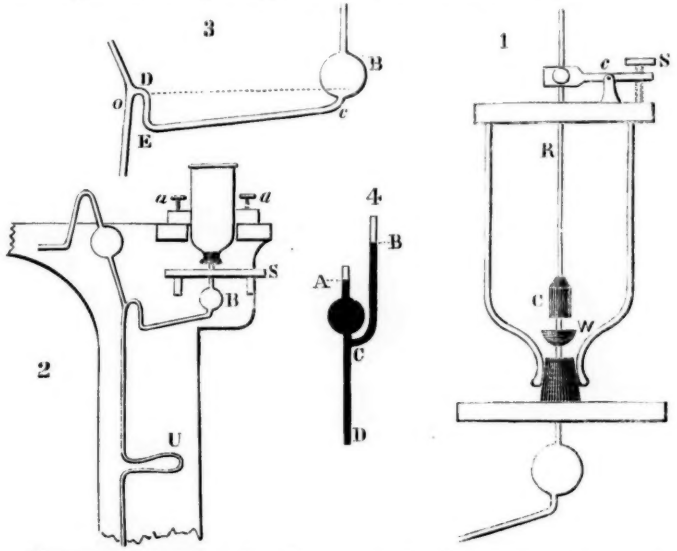
In this experiment, as in the case of the thin diaphragm, absolute contact between the point of the microphone and the surface explored was necessary in order to obtain audible effects. Now I do not mean to deny that sound waves may be originated in the manner suggested by Mr. Preece, but I think that our experiments have demonstrated that the kind of action described by Lord Raleigh actually occurs, and that it is sufficient to account for the audible effects observed.

ART. XVI.—*On a method of obtaining and measuring very high Vacua with a modified form of Sprengel-pump;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

IN the July number of this Journal for 1880, I gave a short account of certain changes in the Sprengel-pump by means of which far better vacuua could be obtained than had been previously possible. For example, the highest vacuum at that time known had been reached by Mr. Crooks, and was about $\frac{1}{17\,000\,000}$, while with my arrangement vacuua of $\frac{1}{100\,000\,000}$ were easily reached. In a notice that appeared in "Nature" for August, 1880, p. 375, it was stated that my improvements were not new, but had already been made in England four years previously. I have been unable to obtain a printed account of the English improvements, and am willing to assume that they are identical with my own; but, on the other hand, as for four years no particular result seems to have followed their introduction in England, I am reluctantly forced to the conclusion that their inventor and his customers, for that period of time, have remained quite in ignorance of the proper mode of utilizing them. Since then I have pushed the matter still farther, and have succeeded in obtaining with my apparatus vacuua as high as $\frac{1}{390\,000\,000}$, without finding that the limit of its action had been reached. The pump is simple in construction, inexpensive and, as I have proved by a large number of experiments, certain in action and easy of use: stopcocks and grease are dispensed with, and when the presence of a stopcock is really desirable its place is supplied by a movable column of mercury.

Reservoir.—An ordinary inverted bell-glass with a diameter of 100^{mm} and a total height of 205^{mm} forms the reservoir; its mouth is closed by a well-fitting cork through which passes the glass tube that forms one termination of the pump. The cork around tube and up to the edge of the former is painted with a flexible cement. The tube projects 40^{mm} into the mercury and passes through a little watch-glass-shaped piece of sheet-iron, W, figure 1, which prevents the small air bubbles that creep upward along the tube from reaching its open end; the little cup is firmly cemented in its place. The flow of the mercury is regulated by the steel rod and cylinder CR, figure 1. The bottom of the steel cylinder is filled out with a circular piece of pure india-rubber, properly cemented; this soon fits itself to the use required and answers admirably. The pressure of the cylinder on the end of the tube is regulated by the lever S, figure 1: this is attached to a circular board which

again is firmly fastened over the open end of the bell-glass. It will be noticed that on turning the milled head S, the motion of the steel cylinder is not directly vertical, but that it tends to describe a circle with *c* as a center; the necessary play of the cylinder is however so small, that practically the experimenter does not become aware of this theoretical defect, so that the arrangement really gives entire satisfaction, and after it has been in use for a few days accurately controls the flow of the mercury. The glass cylinder is held in position, but not supported, by two wooden *adjustable* clamps *a a*, figure 2. The weight of the cylinder and mercury is supported by a shelf, S, figure 2, on which rests the cork of the cylinder; in this way all danger of a very disagreeable accident is avoided.



Vacuum-bulb.—Leaving the reservoir, the mercury enters the vacuum-bulb B, figure 2, where it parts with most of its air and moisture; this bulb also serves to catch the air that creeps into the pump from the reservoir, even when there is no flow of mercury; its diameter is 27^{mm}. The shape and inclination of the tube attached to this bulb is by no means a matter of indifference; accordingly figure 3 is a separate drawing of it; the tube should be so bent that a horizontal line drawn from the proper level of the mercury in the bulb passes through the point *o*, where the drops of mercury break off. The length of the tube EC should be 150^{mm}, that of the tube ED 45^{mm}; the bore of this tube is about the same as that of the fall-tube.

Fall-tube and bends.—The bore of the fall-tube in the pump now used by me is 1·78^{mm}; its length above the bends (U, figure 2) is 310^{mm}; below the bends the length is 815^{mm}. The bends constitute a fluid valve that prevents the air from returning into the pump; beside this, the play of the mercury in them greatly facilitates the passage of the air downward. The top of the mercury column representing the existing barometric pressure should be about 25^{mm} below the bends when the pump is in action. This is easily regulated by an adjustable shelf, which is also employed to fill the bends with mercury when a measurement is taken or when the pump is at rest. On the shelf is a tube, 160^{mm} high and 20^{mm} in diameter, into which the end of the fall-tube dips: its side has a circular perforation into which fits a small cork with a little tube bent at right angles. With the hard end of a file and a few drops of turpentine the perforation can be easily made and shaped in a few minutes. By revolving the little bent tube through 180° the flow of the mercury can be temporarily suspended when it is desirable to change the vessel that catches it.

Gauge.—For the purpose of measuring the vacua I have used an arrangement similar to McLeod's gauge, fig. 4; it has, however, some peculiarities. The tube destined to contain the compressed air has a diameter of 1·35^{mm}, as ascertained by a compound microscope; it is not fused at its upper extremity, but closed by a fine glass rod that fits into it as accurately as may be, the end of the rod being ground flat and true. This rod is introduced into the tube, and while the latter is gently heated a very small portion of the cement described below is allowed to enter by capillary attraction, but not to extend beyond the end of the rod, the operation being watched by a lens. The rod is used for the purpose of obtaining the compressed air in the form of a cylinder and also to allow cleansing of the tube when necessary. The capacity of the gauge-sphere was obtained by filling it with mercury; its external diameter was sixty millimeters; for measuring very high vacua this is somewhat small and makes the probable errors rather large; I would advise the use of a gauge-sphere of about twice as great capacity. The tube CB, figure 4, has the same bore as the measuring tube in order to avoid corrections for capillarity. The tube of the gauge CD is not connected with an india-rubber tube, as is usual, but dips into mercury contained in a cylinder 340^{mm} high, 58^{mm} in diameter, which can be raised and lowered at pleasure. This is best accomplished by the use of a set of boxes of various thicknesses, made for the purpose and supplemented by several sheets of cardboard and even of writing-paper. These have been found to answer well and enable the experimenter to graduate with a nicety the pressure

to which the gas is exposed during measurement. By employing a cylinder filled with mercury instead of the usual caoutchouc tubing small bubbles of air are prevented from entering the gauge along with the mercury. An adjustable brace or support is used which prevents accident to the cylinder when the pump is inclined for the purpose of pumping out the vacuum-bulb. The maximum pressure that can be employed in the gauge used by me is 100^{mm}.

All the tubing of the pump is supported at a distance of about 55^{mm} from the wood-work; this is effected by the use of simple adjustable supports and adjustable clamps; the latter have proved a great convenience. The object is to gain the ability to heat with a Bunsen burner all parts of the pump without burning the wood-work. Where glass and wood necessarily come in contact the wood is protected by metal or simply painted with a saturated solution of alum. The glass portions of the pump I have contrived to anneal completely by the simple means mentioned below. If the glass is not annealed it is certain to crack when subjected to heat, thus causing vexation and loss of time. The mercury was purified by the same method that was used by W. Siemens (Pogg. Annalen, vol. cx, p. 20), that is, by a little strong sulphuric acid to which a few drops of nitric acid had been added; it was dried by pouring it repeatedly from one hot dry vessel to another, by filtering it while quite warm, the drying being completed finally by the action of the pump itself. All the measurements were made by a fine cathetometer which was constructed for me by William Grunow; see this Journal, Jan., 1874, p. 23. It was provided with a well-corrected object-glass having a focal length of 200^{mm}, and as used by me gave a magnifying power of 16 diameters.

Manipulation.—The necessary connections are effected with a cement made by melting Burgundy pitch with three or four per cent of gutta percha. It is indispensable that the cement when cold should be so hard as completely to resist taking any impression from the finger nail, otherwise it is certain to yield gradually and finally to give rise to leaks. The connecting tubes are selected so as to fit as closely as possible, and after being put into position are heated to the proper amount, when the edges are touched with a fragment of cold cement which enters by capillary attraction and forms a transparent joint that can from time to time be examined with a lens for the colors of thin plates, which always precede a leak. Joints of this kind have been in use by me for two months at a time without showing a trace of leakage, and the evidence gathered in another series of unfinished experiments goes to show that no appreciable amount of vapor is furnished by the

resinous compound, which, I may add, is never used until it has been repeatedly melted. As drying material I prefer caustic potash that has been in fusion just before its introduction into the drying tube; during the process of exhaustion it can from time to time be heated nearly to the melting point; if actually fused in the drying tube the latter almost invariably cracks. The pump in the first instance is to be inclined at an angle of about 10 degrees, the tube of the gauge being supported by a semicircular piece of thick paste-board fitted with two corks into the top of the cylinder. This seemingly awkward proceeding has in no case been attended with the slightest accident, and owing to the presence of the four leveling-screws the pump when righted returns, as shown by the telescope of the cathetometer, almost exactly to its original place. In the inclined position the exhaustion of the vacuum-bulb is accomplished along with that of the rest of the pump. The exhaustion of the vacuum-bulb when once effected can be preserved to a great extent for use in future work, merely by allowing mercury from the reservoir to flow in a rapid stream at the time that air is allowed to reënter the pump. During the first process of exhaustion the tube of the gauge is kept hot by moving to and fro a Bunsen burner, and is in this way freed from those portions of air and moisture that are not too firmly attached. After a time the vacuum bulb ceases to deliver bubbles of air; it and the attached tube are now to be heated with a moving Bunsen-burner, when it will be found to furnish for 15 or 20 minutes a large quantity of bubbles mainly of vapor of water. After their production ceases the pump is righted and the exhaustion carried farther. In spite of a couple of careful experiments with the cathetometer I have not succeeded in measuring the vacuum in the vacuum-bulb, but judge from indications, that is about as high as that obtained in an ordinary Geissler pump. Meanwhile the various parts of the pump can be heated with a moving Bunsen-burner to detach air and moisture, the cement being protected by wet lamp-wicking. In one experiment I measured the amount of air that was detached from the walls of the pump by heating them for 10 minutes somewhat above 100° C., and found that it was $\frac{1}{1\,000\,000}$ of the air originally present. I have also noticed that a still larger amount of air is detached by electric discharges. This coincides with an observation of E. Bessel-Hagen in his interesting article on a new form of Töpler's mercury-pump (Annalen der Physik und Chemie, 1881, vol. xii). Even when potash is used a small amount of moisture always collects in the bends of the fall-tube; this is readily removed by a Bunsen-burner; the tension of the vapor being greatly increased, it passes far down the fall-tube in large

bubbles and is condensed. Without this precaution I have found it impossible to obtain a vacuum higher than $\frac{1}{25\,000\,000}$; in point of fact the bends should always be heated when a high exhaustion is undertaken even if the pump has been standing well exhausted for a week; the heat should of course never be applied at a late stage of the exhaustion. Conversely, I have often by the aid of heat completely and quickly removed quite large quantities of the vapor of water that had been purposely introduced. The exhaustion of the vacuum-bulb is of course somewhat injured by the act of using the pump and also by standing for several days, so that it has been usual with me before undertaking a high exhaustion to incline the pump and reëxhaust for 20 minutes; I have however obtained very high vacua without using this precaution.

During the process of exhaustion not more than one-half of the mercury in the reservoir is allowed to run out, otherwise when it is returned bubbles of air are apt to find their way into the vacuum-bulb. In order to secure its quiet entrance it is poured into a silk bag provided with several holes. When the reservoir is first filled its walls for a day or two appear to furnish air that enters the vacuum-bulb; this action, however, soon sinks to a minimum and then the leakage remains quite constant for months together.

Measurement of the vacuum.—The cylinder into which the gauge-tube dips is first elevated by a box sufficiently thick merely to close the gauge, afterwards boxes are placed under it sufficient to elevate the mercury to the base of the measuring tube; when the mercury has reached this point, thin boards and card-boards are added till a suitable pressure is obtained. The length of the enclosed cylinder of air is then measured with the cathetometer, also the height of the mercurial "meniscus," and the difference of the heights of the mercurial columns in A and B, figure 4. To obtain a second measure an assistant removes some of the boxes and the cylinder is lowered by hand three or four centimeters and then replaced in its original position. In measuring really high vacua, it is well to begin with this process of lowering and raising the cylinder, and to repeat it five or six times before taking readings. It seems as though the mercury in the tube B supplies to the glass a coating of air that allows it to move more freely; at all events it is certain that ordinarily the readings of B become regular, only after the mercury has been allowed to play up and down the tube a number of times. This applies particularly to vacua as high as $\frac{1}{50\,000\,000}$ and to pressures of five millimeters and under. It is advantageous in making measurements to employ large pressures and small volumes; the correct working of the gauge can from time to time be tested by varying the relations

of these to each other. This I did quite elaborately, and proved that such constant errors as exist, are small, compared with inevitable accidental errors, as for example that there was no measurable correction for capillarity, that the calculated volume of the "meniscus" was correct, etc. It is essential in making a measurement that the temperature of the room should change as little as possible, and that the temperature of the mercury in the cylinder should be at least nearly that of the air near the gauge-sphere. The computation is made as follows:

n=height of the cylinder enclosing the air;
c=a factor which multiplied by n converts it into cubic millimeters;
S=cubic contents of the meniscus;
d=difference of level between A and B, fig. 4;
=the pressure the air is under;
N=the cubic contents of the guage in millimeters;
x=a fraction expressing the degree of exhaustion obtained: then

$$x = \frac{1}{\frac{N}{\frac{760}{d}}}$$
$$\frac{}{nc - S}$$

It will be noticed that the measurements are independent of the actual height of the barometer, and if several readings are taken continuously, the result will not be sensibly affected by a simultaneous change of the barometer. Almost all the readings were taken at a temperature of about 20° C., and in the present state of the work corrections for temperature may be considered a superfluous refinement.

Gauge correction.—It is necessary to apply to the results thus obtained a correction which becomes very important when high vacua are measured. It was found in an early stage of the experiments that the mercury in the act of entering the highly exhausted gauge, gave out invariably a certain amount of air which of course was measured along with the residuum that properly belonged there; hence to obtain the true vacuum it is necessary to subtract the volume of this air from nc. By a series of experiments I ascertained that the amount of air introduced by the mercury in the acts of entering and leaving the gauge was sensibly constant for six of these single operations (or for three of these double operations), when they followed each other immediately. The correction accordingly is made as follows: the vacuum is first measured as described above, then by withdrawing all the boxes except the lowest, the mercury is allowed to fall so as nearly to empty the gauge; it is then made again to fill the gauge, and these operations are repeated until they amount in all to six; finally the volume and pressure

are a second time measured. Assuming the pressure to remain constant, or that the volumes are reduced to the same pressure,

v=the original volume;
v'=the final volume;
V'=volume of air introduced by the first entry of the mercury;
V=corrected volume; then

$$V' = \frac{v' - v}{6}$$

$$V = v - \frac{v' - v}{6}$$

It will be noticed that it is assumed in this formula that the same amount of air is introduced into the gauge in the acts of entry and exit; in the act of entering in point of fact more fresh mercury is exposed to the action of the vacuum than in the act exit, which might possibly make the true gauge-correction rather larger than that given by the formula. It has been found that when the pump is in constant use the gauge-correction gradually diminishes from day to day: in other words, the air is gradually pumped out of the gauge-mercury. Thus on December 21st, the amount of air entering with the mercury corresponded to an exhaustion of

$\frac{1}{27\,308\,805}$ ------ Dec. 21st.
$\frac{1}{38\,806\,688}$ ------ Dec. 29th.
$\frac{1}{78\,125\,000}$ ------ Jan. 15th.
$\frac{1}{83\,333\,333}$ ------ Jan. 23d.
$\frac{1}{128\,834\,063}$ ------ Feb. 1st.
$\frac{1}{226\,757\,400}$ ------ Feb. 9th.
$\frac{1}{232\,828\,800}$ ------ Feb. 19th.
$\frac{1}{388\,200\,000}$ ------ March 7th.

That this diminution is not due to the air being gradually withdrawn from the walls of the gauge or from the gauge-tube, is shown by the fact that during its progress the pump was several times taken to pieces, and the portions in question exposed to the atmosphere without affecting the nature or extent of the change that was going on. I also made one experiment which proves that the gauge-correction does not

increase sensibly, when the exhausted pump and gauge are allowed to stand unused for twenty days.

Rate of the pump's work.—It is quite important to know the rate of the pump at different degrees of exhaustion, for the purpose of enabling the experimenter to produce a definite exhaustion with facility; also if its maximum rate is known and the minimum rate of leakage, it becomes possible to calculate the highest vacuum attainable with the instrument. Examples are given in the tables below: the total capacity was about 100,000 cubic mm.

Time.	Exhaustion.	Ratio.
10 minutes	$\frac{1}{78\,511}$ to $\frac{1}{1}$	1 : $\frac{1}{3{\cdot}53}$
10 minutes	$\frac{1}{276\,980}$ to $\frac{1}{1}$	1 : $\frac{1}{6{\cdot}10}$
10 minutes	$\frac{1}{1\,687\,140}$ to $\frac{1}{1}$	1 : $\frac{1}{4{\cdot}15}$
	$\frac{1}{7\,002\,000}$	

Upon another occasion the following rates and exhaustions were obtained:

Time.	Exhaustion.	Rate.
10 minutes	$\frac{1}{7\,812\,500}$ to $\frac{1}{1}$	1 : $\frac{1}{3{\cdot}18}$
10 minutes	$\frac{1}{24\,875\,620}$ to $\frac{1}{1}$	1 : $\frac{1}{2{\cdot}69}$
10 minutes	$\frac{1}{67\,024\,090}$ to $\frac{1}{1}$	1 : $\frac{1}{1{\cdot}22}$
10 minutes	$\frac{1}{81\,760\,810}$ to $\frac{1}{1}$	1 : $\frac{1}{1{\cdot}67}$
10 minutes	$\frac{1}{136\,986\,300}$ to $\frac{1}{1}$	1 : $\frac{1}{1{\cdot}23}$
	$\frac{1}{170\,648\,500}$	

The *irregular* variations in the rates are due to the mode in which the flow of the mercury was in each case regulated.

Leakage.—We come now to one of the most important elements in the production of high vacua. After the air is detached from the walls of the pump the leakage becomes and remains nearly constant. I give below a table of leakages, the pump being in each case in a condition suitable for the production of a very high vacuum:

Duration of the experiment.	Leakage per hour in cubic mm., press. 760mm.
18½ hours	·000853
27 hours	·001565
26½ hours	·000791
20 hours	·000842
19 hours	·000951
19 hours	·001857
7 days	·001700
7 days	·001574
Average	·001266

I endeavored to locate this leakage, and proved that one-quarter of it is due to air that enters the gauge from the top of its column of mercury, thus:

Duration of the experiment.	Gauge-leakage per hour in cubic mm., press. 760mm.
18 hours	·0002299
7 days	·0004093
7 days	·0003464
Average	·0003285

This renders it very probable that the remaining three-quarters are due to air given off from the mercury at B, fig. 4, from that in the bends and at the entrance of the fall-tube *o*, fig. 3. Farther on some evidence will be given that renders it probable that the leakage of the pump when in action is about four times as great as the total leakage in a state of rest.

The gauge, when arranged for measurement of gauge-leakage, really constitutes a barometer, and a calculation shows that the leakage would amount to 2·877 cubic millimeters per year press. 760mm. If this air were contained in a cylinder 90mm long and 15mm in diameter it would exert a pressure of ·14mm. To this I may add that in one experiment I allowed the gauge for seven days to remain completely filled with mercury and then measured the leakage into it. This was such as would in a year amount to ·488 cubic millimeters press. 760mm, and in a cylinder of the above dimensions would exert a pressure of ·0233mm.

Reliability of results; highest vacuum.

The following are samples of the results obtained. In one case sixteen readings were taken in groups of four with the following result:

Exhaustion.

$$\frac{1}{74\,219\,139}$$

$$\frac{1}{78\,533\,454}$$

$$\frac{1}{79\,017\,272}$$

$$\frac{1}{68\,503\,182}$$

Mean $$\frac{1}{74\,853\,449}$$

Calculating the probable error of the mean with reference to the above four results it is found to be 2·28 per cent of the quantity involved.

A higher vacuum measured in the same way gave the following results:

$$\frac{1}{146\,198\,800}$$

$$\frac{1}{175\,131\,300}$$

$$\frac{1}{204\,081\,600}$$

$$\frac{1}{201\,207\,200}$$

The mean is $\frac{1}{178\,411\,934}$, with a probable error of 5·42 per cent of the quantity involved. I give now an extreme case; only five single readings were taken; these corresponded to the following exhaustions:

$$\frac{1}{379\,219\,500}$$

$$\frac{1}{371\,057\,265}$$

$$\frac{1}{250\,941\,040}$$

$$\frac{1}{424\,088\,232}$$

$$\frac{1}{691\,082\,540}$$

The mean value is $\frac{1}{381\,100\,000}$, with a probable error of 10·36 per cent of the quantity involved. Upon other occasions I have obtained exhaustions of $\frac{1}{373\,134\,000}$ and $\frac{1}{388\,200\,000}$. Of course in these cases a gauge-correction was applied; the highest vacuum that I have ever obtained irrespective of a gauge-correction was $\frac{1}{190\,392\,150}$. In these cases and in general, potash was employed as the drying material; I have found it practical, however, to attain vacua as high as $\frac{1}{50\,000\,000}$ in the total absence of all such substances. The vapor of water which collects in bends must be removed from time to time with a Bunsen-burner while the pump is in action.

It is evident that the final condition of the pump is reached when as much air leaks in per unit of time as can be removed in the same interval. The total average leakage per ten minutes in the pump used by me, when at rest, was ·000211 cubic millimeters at press. 760^{mm}. Let us assume that the leakage when the pump is in action is four times as great as when at rest; then in each ten minutes ·000844 cubic millimeters press. 760^{mm} would enter; this corresponds in the pump used by me to an exhaustion of $\frac{1}{124\,000\,000}$; if the rate of the pump is such as to remove one-half of the air present in ten minutes, then the highest attainable exhaustion would be $\frac{1}{248\,000\,000}$. In the same way it may be shown that if six minutes are required for the removal of half the air the highest vacuum would be $\frac{1}{413\,000\,000}$ nearly, and rates even higher than this have been observed in my experiments. An arrangement of the vacuum-bulb whereby the entering drops of mercury would be exposed to the vacuum in an isolated condition for a somewhat longer time would doubtless enable the experimenter to obtain considerably higher vacua than those above given.

Exhaustions obtained with a plain Sprengel-pump.—I made a series of experiments with a plain Sprengel-pump without stopcocks, and arranged, as far as possible, like the instrument just described. The leakage per hour was as follows:

Duration of the experiment.	Leakage per hour in cubic mm. at press. 760^{mm}.
22 hours	·04563
2 days	·04520
2 days	·09210
4 days	·06428
Mean	·0618

Using the same reasoning as above we obtain the following table:

Time necessary for removal of $\frac{1}{2}$ the air.	Greatest attainable exhaustion.
10 minutes	$\frac{1}{5\,000\,000}$
7·5 minutes	$\frac{1}{7\,000\,000}$
6·6 minutes	$\frac{1}{12\,000\,000}$

In point of fact the highest exhaustion I ever obtained with this pump was $\frac{1}{8\,000\,000}$; from which I infer that the leakage during action is considerably greater than four times that of the pump at rest. The general run of the experiments tends to show that the leakage of a plain Sprengel-pump, without stopcocks or grease, is, when in action, about 80 times as great as in the form used by me.

Note on annealing glass tubes.—It is quite necessary to anneal all those parts of the pump that are to be exposed to heat, otherwise they soon crack. I found by enclosing the glass in heavy iron tubes and exposing it for five hours to a temperature somewhat above that of melting zinc, and then allowing an hour or two for the cooling process, that the strong polarization figure which it displays in a polariscope was completely removed, and hence the glass annealed. A common gas-combustion furnace was used, the bends, etc., being suitably enclosed in heavy metal and heated over a common ten-fold Bunsen-burner. Thus far no accident has happened to the annealed glass, even when cold drops of mercury struck in rapid succession on portions heated considerably above 100° C.

I wish, in conclusion, to express my thanks to my assistant, Dr. Ihlseng, for the labor he has expended in making the large number of computations necessarily involved in work of this kind.

New York, June 10, 1881

ART. XIX. — *Geological Relations of the Limestone Belts of Westchester County, New York;* by JAMES D. DANA.

ORIGIN OF THE ROCKS OF THE "CORTLANDT SERIES."

IN the account of the massive Cortlandt rocks* I have shown that, although Archæan-like in the presence of the hypersthene-rock, noryte, in the abundance of hornblende and augite, and the occurrence of corundum-bearing magnetite beds, a large part of them afford evidence of conformability to the associated schists and limestone strata of the country, as if one with them in metamorphic origin; and that if any were truly eruptive these were in part more recent than the limestone, since they cut through it at Verplanck Point. They hence present nothing against the chronological conclusion which has been reached.

These rocks, however, are so limited in distribution, and so peculiar in composition—being often chrysolitic, always having soda-lime feldspar predominant, and containing little or no quartz—that it becomes an interesting question, Whence their abrupt interpolation among the schists and limestones of the region.

That the lithological facts may be in mind preparatory to the following discussion I here re-mention the prominent kinds of rocks.

1. *Soda-granite:* granite-like, consisting chiefly of oligoclase and biotite, with little quartz, and often containing some hornblende; varying from coarse to fine in grain, and very light-colored to black—the black very micaceous and fine-grained.

2. *Dioryte, Quartz-dioryte:* chiefly oligoclase and hornblende, with more or less biotite, and a little quartz; varying from very coarse and granite-like to fine-grained.

3. *Noryte:* chiefly the feldspar, andesite—or, more probably, its equivalent, 1 of labradorite and 2 of obligoclase—and hypersthene, with more or less augite and biotite; usually dark gray or reddish brown in color, and rather finely granular; the hypersthene often in small crystals seldom exceeding a sixth of an inch in length, and never in folia.

4. *Augite-noryte:* like the noryte in aspect and constitution, but containing augite in place of the hypersthene.

5. *Hornblendyte:* coarsely crystalline; chiefly black hornblende in small or large cleavable individuals.

6. *Pyroxenyte:* rather coarsely crystalline; chiefly augite, but sometimes a grayish-green pyroxene.

7 to 9. *Chrysolitic hornblendyte, chrysolitic pyroxenyte,* with some chrysolitic noryte.

* This Journal, for September last, III, xx, 194.

Other constituents of these rocks are frequently apatite (which is often in unusual proportions), and more or less magnetite, pyrrhotite and pyrite (the pyrite mostly confined to the soda-granite and dioryte). In the many slices (over 60) which I have microscopically examined, I have found no glassy or unindividualized material, and no appearances of a fluidal character, except that of broken crystals or crystalline grains.

To the description of the noryte before given I here add the results of a careful chemical analysis made in the laboratory of the Sheffield Scientific School of Yale College (under Professor O. D. Allen) by Mr. M. D. Munn of that School. The specimen was from the northern half of Montrose Point, on the Hudson.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	
1.	55·28	16·31	0·69	7·57	0·40	5·05	7·52	4·10	2·05	0·58	=99·55
2.	55·40	16·44	0·85	7·51	0·39	5·05	7·49	4·03	2·00	[0·58]	=99·73
Mean	55·34	16·37	0·77	7·54	0·40	5·05	7·51	4·06	2·03	0·58	=99·65

A trace of CO_2 also was obtained.

To the eye it appeared to contain about as much hypersthene as augite, the crystals of the former being distinguished by a brighter and somewhat bronze-like luster on a cleavage surface, and a less black color; and this proportion was confirmed, as far as could be done, by a microscopic examination of a thin slice. There was present also a little black mica, and some magnetite. The results of the analysis may correspond, if 1·50 of the potash replaces part of the soda, to about 61 per cent of andesite, 33 of bisilicates, 5 of biotite and 1 of magnetite. But part of the potash may be present in orthoclase, and the andesite be, as above recognized, a mixture of labradorite and oligoclase. The analysis appears to show that in constitution the rock approaches closely the dioryte of the region, but with this important difference, that hypersthene and augite are present in place of hornblende and the feldspar portion is more largely basic. The relation to the noryte is much nearer, for one rock graduates into the other; and the hypersthene, which is the characteristic mineral of the former, has the same cleavage angle as augite, and the same constituents, magnesia and iron protoxide, the augite affording besides only lime. Hence the name *augite-noryte* for the rock is appropriate. It has the mineral constitution of the so-called augite-andesyte, and also of a part of what has been included by some writers under the name melaphyre.

The evidence already presented with regard to the Cortlandt rocks sustains the conclusion, as I believe, that to a large extent at least they are of metamorphic origin; but that in the metamorphic process the original beds were rendered (through the heated moisture concerned in the metamorphism), more or less plastic or mobile, so that they thus lost all, or the most of, their original bedding, and that, as a consequence, they formed in some places intrusive dikes or veins intersecting other rocks having all the characteristics of eruptive rocks.

But if "to a large extent" metamorphic, that is, altered sedimentary beds, Why were there, in that narrow corner of Westchester County, covering but twenty-five square miles, beds so unlike ordinary sediments in consisting of the materials of soda-lime feldspars, hornblende, pyroxene, and chrysolite, when, close around and throughout the county to its eastern and southern limits, only ingredients occurred for making common mica schists and gneisses with subordinate layers of hornblende schist?

Before proceeding to this topic I will first mention the facts as to the special geographical position of the area covered by the Cortlandt rocks; and, secondly, briefly review the evidence as to their metamorphic origin. We shall then be prepared to enquire into the source or sources of the material.

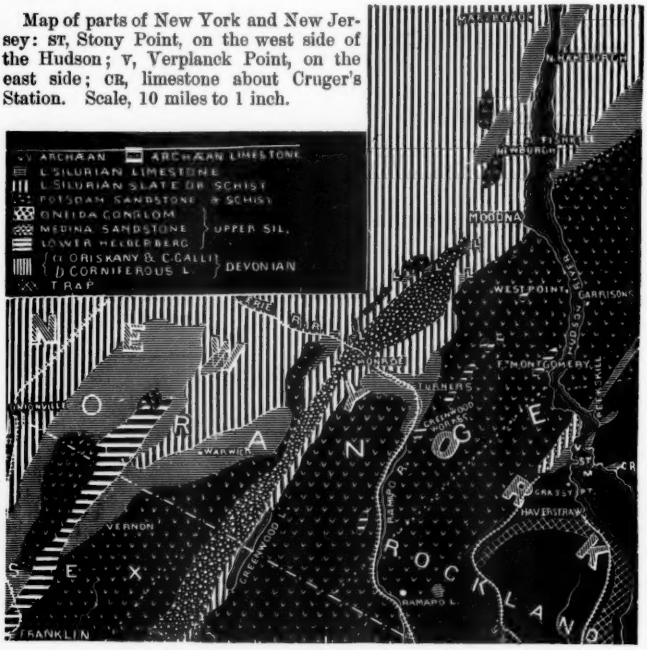
1. *Geographical Position of the Area.*

The small region of Cortlandt rocks is situated in the vicinity of the Hudson, near where this river leaves its channel through the Archæan Highlands. This relation to the position of the Archæan and the river channel is shown on the following map (p. 106). Upon it, the Archæan area is the black portion dotted with small vs, crossing the Hudson, from southwest to northeast, between Moodna and Fishkill on the north and Peekskill on the south: and the Cortlandt rocks occupy the area east of the Archæan, south and southeast of Peekskill on the east of the Hudson, and on Stony Point (ST) on the west side of this river. Near Peekskill the Cortlandt area is separated from the Archæan by belts of limestone (horizontally lined on the map), quartzyte, argillyte-like hydromica schist and mica schist, in all one to three miles in width; and that of Stony Point has, between it and the Archæan, a continuation of the same rocks (the limestone area on the map being, as elsewhere, horizontally lined, and that of the slates, which are partly quartzyte, distinguished by a vertical lining with white and dotted bands). The portion of the map north of the Archæan and occupying valleys within its area, has been already explained as Lower Silurian; (1) limestone, (2) slates or schists (vertically lined), and (3) quartzyte (dotted), the limestone and schist in places fossiliferous; and as part of the great formation which comprises and is continuous with the true Taconic schists and limestone to the northeast, and the recognized Lower Silurian rocks of New Jersey and the States to the southwest.

The larger map of western Cortlandt from Peekskill to Cruger's (comprising the Verplanck peninsula) and also Stony Point is reproduced on the following page, that the positions of the several localities and of the limestone belts may be

more distinctly before the reader, and especially the relations of Stony Point to Montrose Point and other places on the east side of the Hudson.

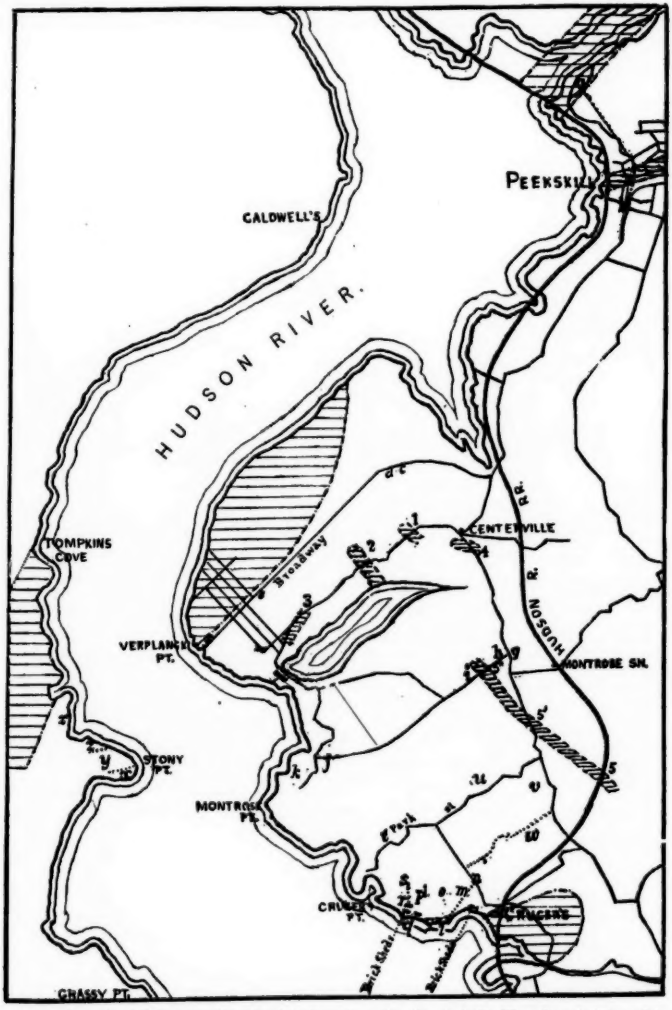
The eastern outline of the Archæan makes a large angle at the crossing of the Hudson (the course on the west being northeast, and that on the east, east-northeast), so that the form was, thus far at least, favorable for the existence there of a broad bay in the Lower Silurian sea. The river-channel through the



Map of parts of New York and New Jersey: ST, Stony Point, on the west side of the Hudson; V, Verplanck Point, on the east side; CR, limestone about Cruger's Station. Scale, 10 miles to 1 inch.

Highlands had not yet been made, as is indicated by the continuity of the Lower Silurian beds on the north of the Highland area across from Fishkill, and that of the same on the south across from Peekskill. The Lower Silurian ocean extended over the Cortlandt area, and here were spread out the sand-beds and muds that now constitute the quartzyte and slates of the Potsdam or Primordial (Cambrian) period and the material of the limestone formation. North of the Archæan, in the Fishkill, Newburgh and Poughkeepsie regions, fossils found in the limestones and hydromica schist have demonstrated that the beds there are beyond question Lower Silurian; and

the like conformable association of quartzyte, slate and semi-crystalline limestone in the Peekskill region, together with their



Map of part of Western Cortlandt, showing the Peekskill, Verplanck, Tompkins Cove, and Cruger limestone areas, by horizontal lining. Scale, 1 inch to a mile.

unconformability to the Archæan, and their relation to New Jersey limestones have been adduced, in my former paper, as proof of a like Lower Silurian age for the Peekskill beds.

A freshwater stream must have emptied into this Cortlandt bay near the present channel of the Hudson; for the general surface of the Highland area and the course of the existing streams over its surface have a pitch southward; but the length of this young Hudson River could hardly have equalled ten miles; for these old lands, as the Lower Silurian in its valleys prove, stood at a lower level than now. This little stream was the chief one that gave aid to the ocean's waters in the work of distributing Archæan detritus over the Cortlandt area. Nothing could have come down the valleys called Canopus Hollow and Peekskill Hollow; for these were for several miles arms of the sea in which limestone beds were accumulating. The cut through the Highlands now occupied by the Hudson was probably begun in a fracture during the making of the Green Mountains at the close of the Lower Silurian.

2. *Metamorphic origin of the Rocks.*

The following are the principal points in the evidence sustaining the view that the rocks are, to a large extent, metamorphosed sedimentary beds.

(1.) The mica schist or micaceous gneiss in several places graduates into the soda-granite along the plane of contact, though always rather abruptly.

(2.) The soda-granite, near its junction with the schist, and sometimes remote from it, contains, at short intervals, distinct layers of the schist, in positions conformable to the bedding outside, and single beds of this kind are in some cases continuous beds for 200 feet or more.

(3.) The mica schist at Cruger's in some parts contains beds that consist largely of staurolite, fibrolite, and magnetite (all infusible species), with abundant scales of silvery mica, a mineral that fuses with great difficulty; and the layers of schist which are in the soda-granite, just north, have a similar constitution; as if they owed their resistance to the fusion which the rest experienced because of their consisting chiefly of these refractory materials.

(4.) The noryte and chrysolite rocks contain, occasionally, similar included conformable beds of schist; and some of these are beds of magnetite and corundum, with fibrolite, that is, are beds of emery; and the noryte is sometimes crossed by gneissic layers and has occasional planes of bedding parallel to the bedding of the limestone near by.

(5.) Since ascending lavas have the motion of a fluid, determined partly as to direction of movement by the friction along the sides, a layer of schist 50 or 100 feet long falling into it would not remain entire, and parallel or conformable to the original schistose rock; and much less could a series of such

layers retain such parallelism. Facts like these are not consistent with the theory of an eruptive origin. Moreover the schists are so firm rocks that the separation of layers by such means would be impossible.

I add one additional fact with regard to these large inclusions. In the brownish-black chrysolitic pyroxenyte which occurs along the south side of Montrose Point, there is *a layer of impure, mostly uncrystalline, gray limestone, eighty feet long* (and probably much longer, as this is only the length of the exposure), *and twelve to eighteen inches wide.* It contains some gray-green tremolite or actinolite in the outer portion, and much disseminated pyrite, and owing to the latter is deeply rusted.

It is almost an impossibility that a thin bed of limestone 80 feet long could by any means have got into the erupted rock; and quite impossible that, if in, it should have held together, and retained from one end to the other, even approximately, a uniform strike and dip (N. 12° E., 70° W.).

(6.) At Verplanck Point, where what look like veins or dikes of pyroxenyte occur in the limestone, they are for the most part conformable to the limestone; as if they might be altered beds; and the more northern of these pseudo-veins *consist of mica schist;* further, these pseudo-veins of the Point are represented half a mile northeast in the line of strike by beds of mica schist or hornblendic schist. Such facts appear to show that the most of the "veins" are beds, metamorphosed into different mineral materials according to their varying constitution; and that the contact phenomena manifested are results of the original passage of one rock into the other along the plane of junction and subsequent metamorphic conditions.

In order to appreciate rightly the bearing of the facts on this question as to metamorphism, the mind should be disabused of the common notion that a massive rock, whether feldspathic, hornblendic or augitic, is necessarily of eruptive origin. As heat and moisture may convert siliceous sand-beds, under pressure, into hard *massive* quartzyte without the intervention of fusion, so also it may convert granitic sand-beds into a granite or granite-like rock, as has happened north of Peekskill. Again, the same means, even when the heat is far below that required for fusion, may destroy molecular cohesion, and, as numerous examples show, may convert, by the recrystallization attending metamorphism, well-bedded strata of hornblendic, augitic or feldspathic material into a massive rock, often undistinguishable even microscopically from an eruptive rock. One example in proof is given in my paper in the June number of this Journal (p. 428); and others in papers on the Helderberg rocks of Bernardston, Mass., and Vernon, Vt.* The layer of

* This Journal, III, vi, 339, 1873 and xiv, 379, 1877.

mostly uncrystalline limestone 80 feet long and a foot or more wide in the chrysolitic rock of Montrose Point indicates a temperature of metamorphism much below that of fusion.

3. *Source of the material of the original beds.*

The characteristics of the beds to be accounted for are: (1) the predominance of the magnesian minerals, hornblende, augite, hypersthene, biotite, chrysolite; (2) the abundance of soda-lime feldspars; and (3) the small proportion of free quartz.

The three supposable sources of such characteristics are—

(1) Detritus from the Archæan Highlands.

(2) Igneous eruptions, affording volcanic or igneous debris, in addition to ejected liquid rock, and along with more or less Archæan detritus.

(3) Detritus from the Highlands, supplemented by ingredients from the ocean.

1. Archæan detritus.

The rocks of the Archæan region of the Highlands are largely hornblendic—the gneiss being often a hornblendic gneiss and varying, in many places, to syenyte-gneiss, true syenyte, and hornblende schist; and the mica, whether hornblende is also present or not, is mostly or wholly the black kind, biotite, which, while containing nearly as much potash as muscovite, is characterized by a large percentage of iron and magnesium. Occasionally augitic rocks are present, especially in the vicinity of beds of iron ore. Augitic and hornblendic rocks abound on Anthony's Nose, which is one of the high summits of the Highlands, just to the north of Cortlandt, and they occur less prominently near West Point.

Magnesian as well as ferriferous sediments might therefore have come from such a source; and the frequent occurrence of hornblende schist in regions of the ordinary metamorphic rocks of Westchester County shows that their formation is nothing exceptional. A feeble proportion of free quartz, as in the Cortlandt rocks, is not an uncommon fact. It characterizes muds or clays which have lost their quartz for making sand-beds in the separating process of wave-action or water-movement, and it is exemplified in much hydromica schist, which often consists of hydrous mica alone, with little, if any, free quartz. Again, the soda-lime feldspar, oligoclase, occurs in the granite and gneiss of the Highlands, and, in fact, is common in these rocks wherever found, though in general subordinately to orthoclase; the Cortlandt rocks are peculiar only in the much larger proportion of soda-lime feldspars. In the Archæan of the Adirondacks, labradorite rocks, closely like the noryte and

augite-noryte of Cortlandt in mineral constitution, cover wide regions; and the same kinds may have formerly existed in the Highlands north of the Cortlandt region, although they have not yet been discovered there; and this is somewhat probable, since a drift specimen has been found in central New Jersey, according to Dr. T. Sterry Hunt, and it is not likely that it came from the distant Adirondacks.

Further: chrysolite, although common in igneous rocks, is also common as a metamorphic product, and occurs even in chloritic and mica schist and other rocks, as should be expected from its composition and easy production by heat.

Doubts with regard to Archæan detritus as the only source of these Cortlandt rocks come from the very abrupt transitions which exist between the hornblendic or augitic rocks and the ordinary mica schists and gneiss, so strongly exemplified in the Verplanck region; in the almost exclusive occurrence over so large an area of soda-lime feldspar rocks, when they are not found in a similar way over any other part of Westchester County, the material of whose rocks, the limestones excepted, must have come from the Highlands; the existence of no similar group of rocks in the great central valley of the New Jersey Highlands (that of Greenwood Lake on the map, page 106), or on their western border, where sedimentary beds of Highland origin were extensively formed. The eastern border of the Archæan in New Jersey is under Triassic beds, so that scarcely anything is known of the Lower Silurian strata directly southwest of Stony Point.

2. Igneous ejections along with more or less Archæan detritus.

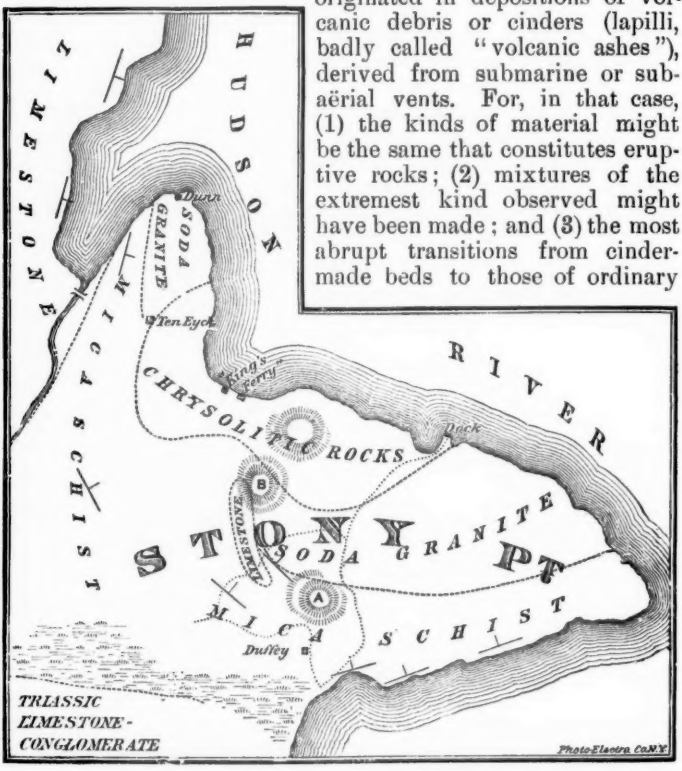
In favor of igneous ejections as a chief source, there are the following facts.

The larger part of the rocks are much like igneous rocks. They resemble them (1) in mineral constitution; (2) in their soda-lime feldspars; (3) in the abundance of hornblende or augite; and (4) in the feeble proportion of quartz. The noryte, though containing hypersthene, offers no objection to the view. The chrysolitic feature of the rocks of some parts of the region is a frequent volcanic characteristic.

But while such resemblances to the igneous rocks exist, it is a striking fact (1) that nowhere in the region are the rocks columnar like those of the Palisades and many regions of augitic igneous rocks; (2) that no vents or dikes have been found to indicate the places of their ejection; (3) that sometimes mixtures of two or three kinds occur—as hornblendyte, pyroxenyte and augite-noryte—which were not combinations made by separate ejections but are merely irregularities of constitution in a single large mass of rock; and occasionally the noryte and

chrysolitic hornblendyte are in united layers each only an inch or two thick; and (4) there are transitions into mica schists not thus easily explained.

These objections appear to prove that the rocks are not truly eruptive. But they do not make it sure that they have not originated in depositions of volcanic debris or cinders (lapilli, badly called "volcanic ashes"), derived from submarine or subaërial vents. For, in that case, (1) the kinds of material might be the same that constitutes eruptive rocks; (2) mixtures of the extremest kind observed might have been made; and (3) the most abrupt transitions from cinder-made beds to those of ordinary



sediments might result, even to the intercalation of a layer of limestone or mica schist, or magnetic iron, or emery, besides all degrees of shading from one to the other; moreover (4) the unique character and contracted limits of the area might in this way be fully explained. Such beds of volcanic debris, afterward undergoing metamorphism simultaneously with the general metamorphism of Westchester County strata, would be likely to come out under the various forms and features presented by the rocks described; and even if, in the process, the heat had not reached that of fusion, portions of the beds permeated with heated moisture might have become

plastic and have been injected into fissures so as to produce dike-like veins, and might retain internal marks of their former mobility in broken crystals, if not in other evidences of flowing.

As to the *centers of eruption*, it is to be noted that the occurrence of chrysolitic rocks on both sides of the Hudson—along the shores of Stony Point on the west and of Montrose Point on the east—with noryte adjoining, and next beyond, the soda-granite, may be an indication that one of them was located in what is now the river channel off the Verplanck shores. (See map, p. 107).

Since my former account of Stony Point was published I have made a further examination of the region with reference to this and other points. The chief facts as to the distribution and positions of the rocks are given in the preceding map.* The *mica schist* of the northwest and south sides of the Point join over the southwestern side; and the strike and dip show that there is here one stratum in a *synclinal* fold. Overlying the schist occurs the *soda-granite* in two areas; and next comes the *chrysolitic rocks*. The chrysolitic rocks thus occupy approximately the middle portion of the synclinal.†

The soda-granite is mostly of the coarsely crystalline, light-colored kind, looking like ordinary granite, but, in the vicinity of the schist, in some parts, a fine-grained variety, gray to black in color, occurs; and the fine variety sometimes intersects the coarse, or the reverse, as if in veins. In one case, near the

* This map is based on a survey of the Point by Mr. L. Wilson, Principal of the Mountain Institute, Haverstraw, N. Y., obligingly made at the request of the writer.

† In my former account of the Point, I showed that the Tompkins Cove limestone stratigraphically underlies the mica schist, it dipping under it, as at Cruger's; and the more recent examination confirms this conclusion. It is therefore probable that the stratum to the north of the Point bends around following the flexure of the schist; and that it lies beneath the area of Triassic conglomerate, and thence extends eastward along the bed of the Hudson.

It is a fact of interest that at Cruger's this overlying schist is *fibrolitic*, just like the overlying gneiss adjoining the limestone of New York Island. The fibrolitic gneiss of 123d street, on the corner of Lexington avenue, is but a few yards from the limestone.

In the interior of the peninsula between the schist and the granite, but quite near the junction with the chrysolitic rock, occurs a thick stratum of limestone (see map, p. 112). It is about conformable to the schist on the south of it, but stops off to the northward with a nearly vertical dip (70°–80° N.) and a strike of N. 70° E. The limestone is situated somewhat like the small beds in the interior of the Verplanck peninsula, and as near to the massive rock; the latter was proved in one case to be conformable to planes of bedding in the neighboring noryte; and in another case, to the mica schist; but the relations of this Stony Point bed to the massive rocks I could not determine. As in Verplanck it is probably a distinct stratum from that of Tompkins Cove; it is semi-crystalline like that, while other parts are coarsely granular, tremolitic and somewhat garnetiferous.

The Tompkins Cove limestone, on the shore just north of the limits of the above map contains many veins of quartz, and assays made for the proprietor, Mr. Edward A. Swain, have proved that the quartz is auriferous.

southern entrance to the grounds a dike (or *vein*) two feet wide, of the black micaceous variety, intersects the *mica schist* cutting obliquely across its bedding.

The direct contact of the granite and chrysolitic rocks is no where in sight. But where the granite ends near the chrysolitic rocks it stands in a nearly vertical wall, having approximately the same strike and dip as the schists to the southeast. The position of the chrysolitic rocks suggests an igneous origin.

With regard to the *time of the ejections*, supposing these a fact, the evidence stands as follows:

The hornblendic and augitic materials occur in conformable beds in the limestone of Verplanck point, looking like dikes or veins because now nearly vertical, as has been explained; and hence this material must have been supplied when the limestone was forming; and the limestone is part of the same stratum, as has been shown, with that of Canopus Hollow, Tompkins Cove and Cruger's Station. Moreover, the dip of the beds seem to indicate that these rocks *overlie* the limestone of the region. Hence the eruptions were in progress while the limestone was forming, and continued on for a period after it.

It may be objected to this view of an igneous source that the chrysolitic pyroxenyte and hornblendyte are very unlike ordinary igneous chrysolitic rocks, the chrysolite never being in glassy grains; that chrysolitic pyroxenyte, though a known kind, is not in all cases igneous; and that chrysolitic hornblendyte like that here met with (having hornblende cleavage faces measuring sometimes two inches each way) is still less like an igneous product. So, also, soda-granite is a very unusual form of eruptive rock, and likewise dioryte with crystals of hornblende sometimes eight or nine inches long, like that near Cruger's. But these difficulties, and others like them, lose much of their force in view of the fact that the beds may contain more or less ordinary detritus, as well as volcanic debris, and especially the other fact that they have undergone metamorphism since their deposition, and in some cases have thereby suffered partial or complete fusion.

Again, it may be urged in objection that we have no definite evidence as to the former existence of such a vent in the channel of the Hudson, or of any other in the region. This objection may hereafter be strengthened, or, on the other hand, weakened, by finding that among the dikes of igneous rocks which intersect the Archæan in various places, some, or none, consist of rocks similar to those of Cortlandt.

Professor Cook, in his Geological Report of 1868, at page 144, has described a labradorite rock, resembling somewhat the

Cortlandt noryte or augite-noryte, as occurring forty miles west of the Hudson on the east slope of the Kittatinny Mountains, not far west of Libertyville and Deckertown (between *c* and *d* on the map, Plate IX, in this Journal for last November); and he speaks of it as constituting a dike a fourth of a mile wide and several miles long, coming in between the Hudson River slate and the overlying Oneida Conglomerate, and conforming to them in strike. In a recent letter to the writer he observes that the question as to whether eruptive or not he does not consider as settled, the debris of the region having prevented satisfactory examination. The adjoining slates are stated to be modified, as if from the influence of the mass, for 3,000 feet to the eastward—a distance so great that the effects can hardly be all due to contact. The further study of that region may throw light on the Cortlandt rocks.

(3.) ARCHÆAN DETRITUS, SUPPLEMENTED BY MATERIALS FROM THE OCEAN.

The chief stony materials which the ocean's waters have to contribute are: (1) the *calcareous*—calcium carbonate mainly through the secretions (shells, corals, etc.) of its living species, and calcium chloride; (2) the *magnesian*, from the magnesium chloride and sulphate; and (3) the *soda*, through the sodium chloride or common salt.

The calcareous and magnesian materials of the oceanic waters have been of immense importance in rock-making. The limestones of the world have originated from the former. Besides this, few muds or argillaceous sand beds have been made since the first Rhizopods appeared that have not contained more or less disseminated calcareous material; and this material, in the course of the metamorphism of those beds, has been often employed in producing some of the new combinations constituting metamorphic rocks. So, also, the ocean has been the chief source of the magnesia used for making dolomite, or magnesian limestone, and for other purposes. In the case of the limestone of Westchester County, which is dolomitic, the magnesia was taken from the sea-water, according to the most generally accepted view, while the process of consolidation was going on in great marshes of concentrated saline waters.

Further, when the magnesian limestones thus made were afterward rendered metamorphic, part of the magnesia and lime (or magnesium and calcium) was in many cases made into silicates, such as tremolite, white pyroxene, and other species; or, when iron has also been present, into other related silicates of light or dark green tints, as hornblende, actinolite, green pyroxene; and also into other magnesian minerals through other impurities of the limestone.

Thus the magnesia of the ocean's waters has beyond doubt

supplemented that of detritus in determining the constitution of metamorphic rocks, and has led especially to the production of different varieties of hornblende and pyroxene, the darker kinds resulting when the all-pervading ingredient, iron, was present.

Further, the ocean has been one of the sources of soda in rock-making. The contributions of this nature to sedimentary deposits, are, as is well known, common and extensive. Beds of rock salt, sometimes of great thickness, occur in formations of various ages, from the Silurian to the present time; and magnesian salts, derived, directly or indirectly, from the same sea-waters that afforded the rock salt, are also frequently present.

Moreover, brines from deep borings are common. It is not necessary here to give details. I mention two American cases only, one relating to the Lower Silurian formation, and the other pertaining to the vicinity of the region under discussion.

The boring at the St. Louis Insane Asylum, reported upon by Mr. G. C. Broadhead, State Geologist of Missouri,* which penetrated through Carboniferous and Lower Silurian strata into the Archæan, reached a depth of 3,843½ feet. "Salt water" was obtained in the Lower Silurian (Magnesian limestone) at a depth of 1,220 feet and below. At 2,256 feet, the water contained 3 per cent of salt; at 2,957 feet, 4½ per cent; at 3,293 feet, 2 per cent; and below 3,545 feet, 7 to 8 per cent.

Prof. G. H. Cook, State Geologist of New Jersey, states in his Report for the year 1880, that from a boring in the Triassic sandstone at Patterson in that State (which is in the same geographical region with the Cortlandt area, it lying to the east of the Archæan Highlands) the water obtained at 2,050 feet afforded, per gallon, 408·46 grains of sodium chloride, with 109·44 of magnesium chloride and 278·32 of calcium chloride —which shows the presence of about half the proportion of salt contained in sea-water, and of a much larger proportion of magnesium and calcium chlorides than sea water contains; and Prof. Cook adds: "the questions suggested by finding the salt water must remain for the present unanswered, though the fact that the rock-salt of Europe is found in rocks of the same age as this raises the question whether it may not also be found here."

Rocks containing salt in beds or brines have undoubtedly undergone metamorphism, and under conditions as to superincumbent formations which permitted of no escape of the sodium, and which therefore would have forced it into chemical combination with the other materials present. And if it has entered into any minerals the feldspars must be among them,

* Report on the Geological Survey of Missouri for 1873–1874, 8vo, p. 32. 1874.

since these are the commonest of anhydrous sodium silicates. Science looks to the ocean for the boric acid of some minerals and the chlorine and iodine of certain silver ores and some volcanic products; and hence referring to it as a source of the more stable bases with which these were combined is not unreasonable.

In Savoy, as has long been known, the crystalline magnesian limestone or dolomite of the Trias contains the soda-feldspar, albite, in disseminated crystals. The magnesia of the limestone must have come from evaporated sea-water as above explained; and the soda of the feldspar which, in the metamorphic process that crystallized the dolomite, went to make albite may have had the same source.

Messrs. F. Fouqué and Michel Lévy have recently made* crystallized oligoclase and labradorite by heating a mixture of silica, alumina (each of these in the states obtained by precipitation), sodium carbonate and calcium carbonate in the required proportions, and keeping it in prolonged fusion. They have thus proved that the sodium of a sodium carbonate will, at a high temperature, enter into combination and make feldspars. The sodium of sodium chloride (common salt) would in all probability yield the same result; as is indicated by the use of common salt in putting a glazing on porcelain (while it is at a high heat) the chlorine escaping and yielding the sodium to make a silicate, or the glaze. The possibility of producing soda-lime feldspar in the metamorphism of a saliferous sedimentary stratum has therefore been put beyond question by actual experiment. Metamorphic heat would be as effectual; and, with the aid of moisture, probably at a lower temperature than that employed by Fouqué.

Crystalline rocks made largely of soda-lime feldspars,—some of which are diorite, noryte, and the labradorite rocks called gabbro—covering many large regions, are in some cases unquestionably of metamorphic origin; and if detritus from pre-existing rocks were not a sufficient source for the soda of the feldspars and the magnesia of the hornblende or augite, and a volcanic or igneous source is not indicated by surrounding conditions, there must have been at hand some other large and abundant source; and the universal ocean is of just the kind needed. Near New Haven, Connecticut, a chloritic hydromica schist contains, along a certain horizon, interrupted beds or lenticular masses of limestone—parts of which are more or less changed to serpentine and verd-antique marble; and below the limestone horizon, the schist, for a considerable thickness, contains irregular masses of labradioryte (labradorite-dioryte), the slaty-beds of the schist changing for short distances to labra-

* Comptes Rendus, vol. lxxxvii, pp. 700 and 779, November, 1878.

dioryte and then back again to slate, in the most irregular way. The idea of an eruptive origin is utterly out of the question; and that of a "volcanic-ash" origin for the material has nothing to sustain it, since not even one small dike of igneous rock or any other evidence of igneous eruption older than Triassic has yet been found within a circuit of fifty miles; and what there are of veins in the older rocks are made of granitic or siliceous material. Since these isolated portions of massive labradioryte are parts of a stratum lying directly beneath the limestone horizon, which stratum would be likely to be more or less calcareous through an organic source, the lime of the labradorite in this rock may be only the calcareous portion of the original sediments; and what additional soda was needed may have come from the permeating brine water. This example may illustrate the mode of origin of other metamorphic labradorite and oligoclase rocks.

The hypothesis that the massive Cortlandt rocks were made by the above-explained method—that is from "ordinary detritus supplemented by materials from the ocean"—is therefore not wholly improbable. It is still less so when some details connected with it are considered.

The position of the area—in the angle between the New Jersey and Putnam County Highlands, the site of a Lower Silurian bay—was favorable for the occurrence of the required conditions. The limestone (dolomite) shows, by its magnesia, that during the long era in which it was accumulating from the organic secretions of the waters, evaporating brine-making sea-marshes prevailed, or alternated with open seas, over the shallow bay. The beds of fine mica schist, one to ten feet thick, which occur intercalated in the limestone, northeast of Verplanck Point, show that the sea-marshes in some parts became covered at intervals with mud-deposits containing (as the black mica proves, and also the hornblende and augite present in some of the schist) iron oxide and magnesia. And, finally, the occurrence just southwest, at Verplanck Point, in the same limestone, of conformable intercalations of noryte, pyroxenyte and hornblendyte—the massive Cortlandt rocks containing little of the black mica—and, by the side of these, some true mica schist beds, accords with the view that in this part of the area the depositions of common and magnesian salts from the marsh were at some horizons of the detritus more abundant than to the northeast. The nearly total absence of free silica may have its explanation also in these conditions, since the bases contributed by the sea-water, the soda, magnesia and lime, together with the iron from outside sources, would have needed it to make the silicates. If these are the right explanations for the facts at Verplanck Point, the principle is

equally good for all in the Cortlandt and Stony Point area, and for all variations in the kinds and the thicknesses of the rocks, and their intercalations. Whether true or not, it must, after the survey of the facts, be admitted to be nothing against it that the rocks are massive crystalline rocks; that among them are hornblendic and augitic kinds containing soda-lime feldspars, and that some of them are chrysolitic.

Having presented the claims of the three hypotheses, I leave the subject without expressing a personal opinion.

The Appendix to this memoir, to which allusion has been made, will appear in a following number of this Journal.

ART. XX.—*On a new Meteoric Iron, of unknown locality, in the Smithsonian Museum;* by CHARLES UPHAM SHEPARD.

HAVING received a fragment from a meteoric iron, of unknown locality, belonging to the Museum of the Smithsonian Institution, I have made an examination of it with the following results:

The mass was oval in form, with three or four prominent knobs. Its weight was probably about six pounds. The fragment for examination was separated with considerable facility, requiring only a few smart blows of the hammer; and revealed a crystalline structure. The surfaces developed were partially covered by an exceedingly thin, micaceous layer of schreibersite. After polishing, the fragment had a somewhat whiter color than artificial iron. When etched, it showed a homogeneous, finely crystalline texture, and became still whiter in color. When viewed at fixed angles of reflexion, the surface glimmered simultaneously, after the manner of sunstone oligoclasite, thus rendering it probable that the crystallization of the general mass was that of a single individual.

It is obscurely banded, in some portions, with bars about $\frac{1}{20}$th of an inch in thickness. But the most remarkable feature of the etched surface is its thickly dotted or punctate character; the dots which are very bright, instead of being salient points, are slightly concave. On the whole, therefore, this iron differs in structure from any meteoric iron thus far known. The composition, as determined by C. U. Shepard, Jr., is

Iron	92·923
Nickel	6·071
Cobalt	0·539
Schreibersite (phosphide of iron)	0·562—100·095

There are traces also of copper and tin. The polished surfaces show no tendeny to deliquescence. Sp. gr.=7·589.

Charleston, Feb. 19, 1881.

ART. XXI.—*The relative motion of the Earth and the Luminiferous ether;* by ALBERT A. MICHELSON, Master, U. S. Navy.

THE undulatory theory of light assumes the existence of a medium called the ether, whose vibrations produce the phenomena of heat and light, and which is supposed to fill all space. According to Fresnel, the ether, which is enclosed in optical media, partakes of the motion of these media, to an extent depending on their indices of refraction. For air, this motion would be but a small fraction of that of the air itself and will be neglected.

Assuming then that the ether is at rest, the earth moving through it, the time required for light to pass from one point to another on the earth's surface, would depend on the direction in which it travels.

Let V be the velocity of light.

v = the speed of the earth with respect to the ether.

D = the distance between the two points.

d = the distance through which the earth moves, while light travels from one point to the other.

d_1 = the distance earth moves, while light passes in the opposite direction.

Suppose the direction of the line joining the two points to coincide with the direction of earth's motion, and let T = time required for light to pass from the one point to the other, and T_1 = time required for it to pass in the opposite direction. Further, let T_0 = time required to perform the journey if the earth were at rest.

$$\text{Then } T=\frac{D+d}{V}=\frac{d}{v}; \text{ and } T_1=\frac{D-d}{V}=\frac{d_1}{v}$$

From these relations we find $d=D\frac{v}{V-v}$ and $d_1=D\frac{v}{V+v}$

whence $T=\frac{D}{V-v}$ and $T_1=\frac{D}{V+v}$; $T-T_1=2T_0\frac{v}{V}$ *nearly*, and $v=V\frac{T-T_1}{2T_0}$.

If now it were possible to measure $T-T_1$ since V and T_0 are known, we could find v the velocity of the earth's motion through the ether.

In a letter, published in "Nature" shortly after his death, Clerk Maxwell pointed out that $T-T_1$ could be calculated by measuring the velocity of light by means of the eclipses of Jupiter's satellites at periods when that planet lay in different directions from earth; but that for this purpose the observations of these eclipses must greatly exceed in accuracy those

which have thus far been obtained. In the same letter it was also stated that the reason why such measurements could not be made at the earth's surface was that we have thus far no method for measuring the velocity of light which does not involve the necessity of returning the light over its path, whereby it would lose nearly as much as was gained in going.

The difference depending on the square of the ratio of the two velocities, according to Maxwell, is far too small to measure.

The following is intended to show that, with a wave-length of yellow light as a standard, the quantity—if it exists—is easily measurable.

Using the same notation as before we have $T=\frac{D}{V-v}$ and $T_1=\frac{D}{V+v}$. The whole time occupied therefore in going and returning $T+T_1=2D\frac{V}{V^2-v^2}$. If, however, the light had traveled in a direction at right angles to the earth's motion it would be entirely unaffected and the time of going and returning would be, therefore, $2\frac{D}{V}=2T_0$. The difference between the times $T+T_1$ and $2T_0$ is

$$2DV\left(\frac{1}{V^2-v^2}-\frac{1}{V^2}\right)=\tau;\ \tau=2DV\frac{v^2}{V^2(V^2-v^2)}$$

or nearly $2T_0\frac{v^2}{V^2}$. In the time τ the light would travel a distance $V\tau=2VT_0\frac{v^2}{V^2}=2D\frac{v^2}{V^2}$.

That is, the actual distance the light travels in the first case is greater than in the second, by the quantity $2D\frac{v^2}{V^2}$.

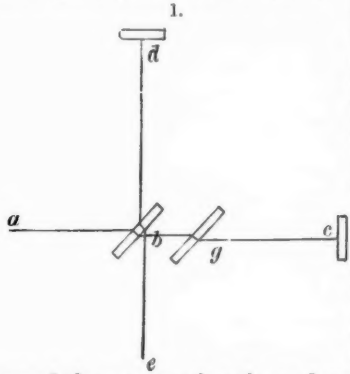
Considering only the velocity of the earth in its orbit, the ratio $\frac{v}{V}=\frac{1}{10\,000}$ approximately, and $\frac{v^2}{V^2}=\frac{1}{100\,000\,000}$. If D = 1200 millimeters, or in wave-lengths of yellow light, 2 000 000, then in terms of the same unit, $2D\frac{v^2}{V^2}=\frac{4}{100}$.

If, therefore, an apparatus is so constructed as to permit two pencils of light, which have traveled over paths at right angles to each other, to interfere, the pencil which has traveled in the direction of the earth's motion, will in reality travel $\frac{4}{100}$ of a wave-length farther than it would have done, were the earth at rest. The other pencil being at right angles to the motion would not be affected.

If, now, the apparatus be revolved through 90° so that the second pencil is brought into the direction of the earth's motion, its path will have lengthened $\frac{4}{100}$ wave-lengths. The total change in the position of the interference bands would be $\frac{8}{100}$ of the distance between the bands, a quantity easily measurable.

The conditions for producing interference of two pencils of light which had traversed paths at right angles to each other were realized in the following simple manner.

Light from a lamp *a*, fig. 1, passed through the plane parallel glass plate *b*, part going to the mirror *c*, and part being reflected to the mirror *d*. The mirrors *c* and *d* were of plane glass, and silvered on the front surface. From these the light was reflected to *b*, where the one was reflected and the other refracted, the two coinciding along *be*.



The distance *bc* being made equal to *bd*, and a plate of glass *g* being interposed in the path of the ray *bc*, to compensate for the thickness of the glass *b*, which is traversed by the ray *bd*, the two rays will have traveled over equal paths and are in condition to interfere.

The instrument is represented in plan by fig. 2, and in perspective by fig. 3. The same letters refer to the same parts in the two figures.

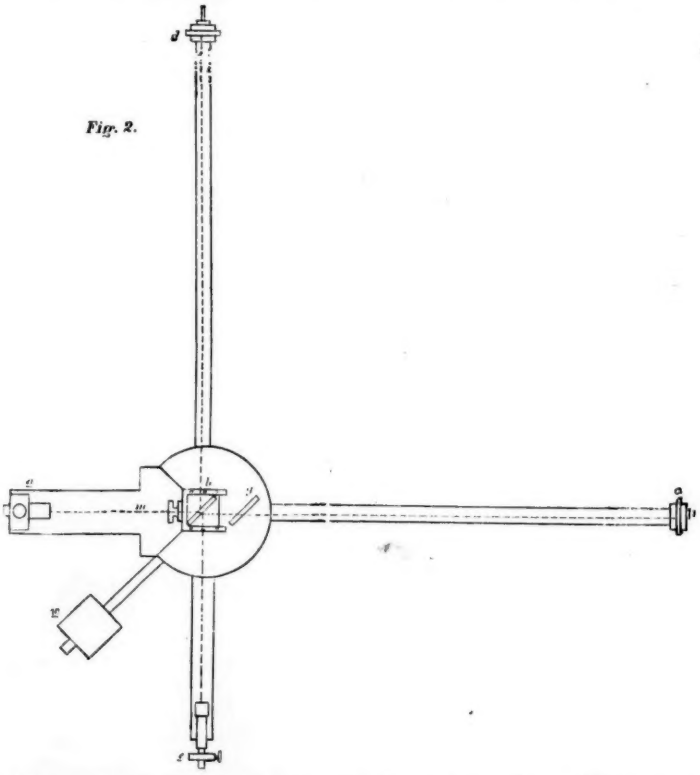
The source of light, a small lantern provided with a lens, the flame being in the focus, is represented at *a*. *b* and *g* are the two plane glasses, both being cut from the same piece; *d* and *c* are the silvered glass mirrors; *m* is a micrometer screw which moves the plate *b* in the direction *bc*. The telescope *e*, for observing the interference bands, is provided with a micrometer eyepiece. *w* is a counterpoise.

In the experiments the arms, *bd*, *bc*, were covered by long paper boxes, not represented in the figures, to guard against changes in temperature. They were supported at the outer ends by the pins *k*, *l*, and at the other by the circular plate *o*. The adjustments were effected as follows:

The mirrors *c* and *d* were moved up as close as possible to the plate *b*, and by means of the screw *m* the distances between a point on the surface of *b* and the two mirrors were made approximately equal by a pair of compasses. The lamp being

lit, a small hole made in a screen placed before it served as a point of light; and the plate *b*, which was adjustable in two planes, was moved about till the two images of the point of light, which were reflected by the mirrors, coincided. Then a sodium flame placed at *a* produced at once the interference bands. These could then be altered in width, position, or direction, by a slight movement of the plate *b*, and when they were of convenient width and of maximum sharpness, the

Fig. 2.



sodium flame was removed and the lamp again substituted. The screw *m* was then slowly turned till the bands reappeared. They were then of course colored, except the central band, which was nearly black. The observing telescope had to be focussed on the surface of the mirror *d*, where the fringes were most distinct. The whole apparatus, including the lamp and the telescope, was movable about a vertical axis.

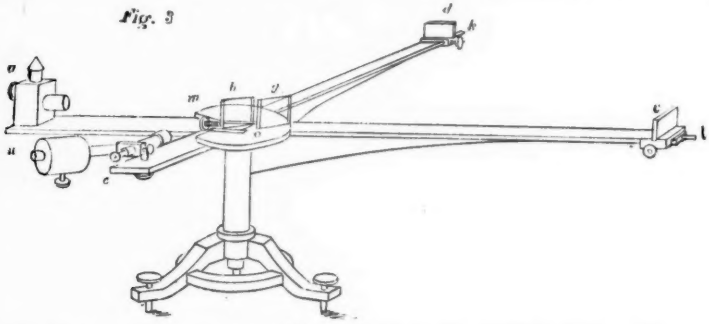
It will be observed that this apparatus can very easily be

made to serve as an "interferential refractor," and has the two important advantages of small cost, and wide separation of the two pencils.

The apparatus as above described was constructed by Schmidt and Hænsch of Berlin. It was placed on a stone pier in the Physical Institute, Berlin. The first observation showed, however, that owing to the extreme sensitiveness of the instrument to vibrations, the work could not be carried on during the day. The experiment was next tried at night. When the mirrors were placed half-way on the arms the fringes were visible, but their position could not be measured till after twelve o'clock, and then only at intervals. When the mirrors were moved out to the ends of the arms, the fringes were only occasionally visible.

It thus appeared that the experiments could not be performed in Berlin, and the apparatus was accordingly removed

Fig. 3



to the *Astrophysicalisches Observatorium* in Potsdam. Even here the ordinary stone piers did not suffice, and the apparatus was again transferred, this time to a cellar whose circular walls formed the foundation for the pier of the equatorial.

Here, the fringes under ordinary circumstances were sufficiently quiet to measure, but so extraordinarily sensitive was the instrument that the stamping of the pavement, about 100 meters from the observatory, made the fringes disappear entirely!

If this was the case with the instrument constructed with a view to avoid sensitiveness, what may we not expect from one made as sensitive as possible!

At this time of the year, early in April, the earth's motion in its orbit coincides roughly in longitude with the estimated direction of the motion of the solar system—namely, toward the constellation Hercules. The direction of this motion is inclined at an angle of about +26° to the plane of the equator,

and at this time of the year the tangent of the earth's motion in its orbit makes an angle of $-23\frac{1}{2}°$ with the plane of the equator; hence we may say the resultant would lie within 25° of the equator.

The nearer the two components are in magnitude to each other, the more nearly would their resultant coincide with the plane of the equator.

In this case, if the apparatus be so placed that the arms point north and east at noon, the arm pointing east would coincide with the resultant motion, and the other would be at right angles. Therefore, if at this time the apparatus be rotated 90°, the displacement of the fringes should be *twice* $\frac{8}{100}$ or 0·16 of the distance between the fringes.

If, on the other hand, the proper motion of the sun is small compared to the earth's motion, the displacement should be $\frac{4}{10}$ of ·08 or 0·048. Taking the mean of these two numbers as the most probable, we may say that the displacement to be looked for is not far from one-tenth the distance between the fringes.

The principal difficulty which was to be feared in making these experiments, was that arising from changes of temperature of the two arms of the instrument. These being of brass whose coefficient of expansion is 0·000019 and having a length of about 1000 mm. or 1 700 000 wave-lengths, if one arm should have a temperature only one one-hundredth of a degree higher than the other, the fringes would thereby experience a displacement three times as great as that which would result from the rotation. On the other hand, since the changes of temperature are independent of the direction of the arms, if these changes were not too great their effect could be eliminated.

It was found, however, that the displacement on account of bending of the arms during rotation was so considerable that the instrument had to be returned to the maker, with instructions to make it revolve as easily as possible. It will be seen from the tables, that notwithstanding this precaution a large displacement was observed in one particular direction. That this was due entirely to the support was proved by turning the latter through 90°, when the direction in which the displacement appeared was also changed 90°.

On account of the sensitiveness of the instrument to vibration, the micrometer screw of the observing telescope could not be employed, and a scale ruled on glass was substituted. The distance between the fringes covered three scale divisions, and the position of the center of the dark fringe was estimated to fourths of a division, so that the separate estimates were correct to within $\frac{1}{12}$.

It frequently occurred that from some slight cause (among

others the springing of the tin lantern by heating) the fringes would suddenly change their position, in which case the series of observations was rejected and a new series begun.

In making the adjustment before the third series of observations, the direction in which the fringes moved, on moving the glass plate *b*, was reversed, so that the displacement in the third and fourth series are to be taken with the opposite sign.

At the end of each series the support was turned 90°, and the axis was carefully adjusted to the vertical by means of the foot-screws and a spirit level.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	NW.	Remarks.
1st revolution	0·0	0·0	0·0	−8·0	−1·0	−1·0	−2·0	−3·0	Series 1, footscrew
2d "	16·0	16·0	16·0	9·0	16·0	16·0	15·0	13·0	marked B, toward
3d "	17·0	17·0	17·0	10·0	17·0	16·0	16·0	17·0	East.
4th "	15·0	15·0	15·0	8·0	14·5	14·5	14·5	14·0	
5th "	13·5	13·5	13·5	5·0	12·0	13·0	13·0	13·0	
	61·5	61·5	61·5	*x*	58·5	58·5	56·5	54·0	
S.	58·5	W.	56·5		N.E.	61·5	S.E.	60·0	
	120·0		118·0			120·0		114·0	
	118·0					114·0			
Excess,	+2·0					+6·0			
1st revolution	10·0	11·0	12·0	13·0	13·0	0·0	14·0	15·0	Series 2, B toward
2d "	16·0	16·0	16·0	17·0	17·0	2·0	17·0	17·0	South.
3d "	17·5	17·5	17·5	17·5	17·5	4·0	18·0	17·5	
4th "	17·5	17·5	17·0	17·0	17·0	4·0	17·0	17·0	
5th "	17·0	17·0	17·0	17·0	16·0	3·0	16·0	16·0	
	78·0	79·0	79·5	81·5	80·5	*x*	82·0	82·5	
S.	80·5	W.	82·0		N.E.	79·0	S.E.	81·5	
	158·5		161·5			160·0		164·0	
	161·5					164·0			
Excess,	−3·0					−4·0			
1st revolution	3·0	3·0	3·0	3·0	2·5	2·5	2·5	10·0	Series 3. B toward
2d "	18·0	17·5	17·5	18·0	18·5	19·0	19·5	26·0	West.
3d "	11·0	11·0	13·0	12·0	13·0	13·5	13·5	21·0	
4th "	1·0	0·0	0·5	0·5	0·5	0·0	0·0	14·0	
5th "	4·0	4·0	5·0	5·0	5·0	5·5	5·5	16·0	
	37·0	35·5	39·0	38·5	39·5	40·5	71·0	*x*	
S.	39·5	W.	41·0		N.E.	35·5	S.E.	38·5	
	76·5		80·0			76·0		79·5	
			76·5					76·0	
Excess,			+3·5					+3·5	
1st revolution	14·0	21·0	15·5	17·0	14·0	14·5	14·5	16·0	Series 4, B toward
2d "	10·0	20·0	12·0	12·0	13·0	13·0	13·0	13·5	North.
3d "	14·0	25·0	15·0	16·0	16·0	16·0	16·0	17·0	
4th "	18·0	27·0	18·5	18·5	18·5	19·0	20·0	21·0	
5th "	15·0	24·0	15·0	15·0	15·0	16·0	16·0	16·5	
	71·0	*x*	76·0	78·5	76·5	78·5	79·5	84·0	
S.	76·5	W.	79·5		N.E.	73·5	S.E.	78·5	
	147·5		155·5			152·0		162·5	
			147·5					152·0	
Excess,			+8·0					+10·5	

The heading of the columns in the table gives the direction toward which the telescope pointed.

The footing of the erroneous column is marked x, and in the calculations the mean of the two adjacent footings is substituted.

The numbers in the columns are the positions of the center of the dark fringe in *twelfths* of the distance between the fringes.

In the first two series, when the footings of the columns N. and S. exceed those of columns E. and W., the excess is called positive. The excess of the footings of N.E., S.W., over those of N.W., S.E., are also called positive. In the third and fourth series this is reversed.

The numbers marked "excess" are the sums of ten observations. Dividing therefore by 10, to obtain the mean, and also by 12 (since the numbers are twelfths of the distance between the fringes), we find for

	N.S.	N.E., S.W.
Series 1	+0·017	+0·050
" 2	−0·025	−0·033
" 3	+0·030	+0·030
" 4	+0·067	+0·087
	4 ⌋ 0·089	0·137
Mean =	+0·022	+0·034

The displacement is, therefore,

In favor of the columns N.S.	+0·022
" " " N.E., S.W.	+0·034

The former is too small to be considered as showing a displacement due to the simple change in direction, and the latter should have been zero.

The numbers are simply outstanding errors of experiment. It is, in fact, to be seen from the footings of the columns, that the numbers increase (or decrease) with more or less regularity from left to right.

This gradual change, which should not in the least affect the periodic variation for which we are searching, would of itself necessitate an outstanding error, simply because the sum of the two columns farther to the left must be less (or greater) than the sum of those farther to the right.

This view is amply confirmed by the fact that where the excess is positive for the column N.S., it is also positive for N.E., S.W., and where negative, negative. If, therefore, we can eliminate this gradual change, we may expect a much smaller error. This is most readily accomplished as follows:

Adding together all the footings of the four series, the third and fourth with negative sign, we obtain

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
31·5	31·5	26·0	24·5	23·0	20·8	18·0	11·0

or dividing by 20×12 to obtain the means in terms of the distance between the fringes,

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
0·131	0·131	0·108	0·102	0·096	0·086	0·075	0·046

If x is the number of the column counting from the right and y the corresponding footing, then the method of least squares gives as the equation of the straight line which passes nearest the points x, y—

$$y = 9{\cdot}25x + 64{\cdot}5$$

If, now, we construct a curve with ordinates equal to the difference of the values of y found from the equation, and the actual value of y, it will represent the displacements observed, freed from the error in question.

These ordinates are:

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
−·002	−·011	+·003	−·001	−·004	−·003	−·001	+·018

N.	−·002	E.	+·003	N.E.	−·011	N.W.	+·018
S.	−·004	W.	−·001	S.W.	−·003	S.E.	−·001
Mean=	−·003		+·001	Mean=	−·007		+·008
	+·001				+·008		
Excess=	−·004			Excess=	−·015		

The small displacements $-0{\cdot}004$ and $-0{\cdot}015$ are simply errors of experiment.

The results obtained are, however, more strikingly shown by constructing the actual curve together with the curve that should have been found if the theory had been correct. This is shown in fig. 4.

4.

The dotted curve is drawn on the supposition that the displacement to be expected is one-tenth of the distance between the fringes, but if this displacement were only $\frac{1}{100}$, the broken line would still coincide more nearly with the straight line than with the curve.

The interpretation of these results is that there is no displacement of the interference bands. The result of the hypothesis of a stationary ether is thus shown to be incorrect, and the necessary conclusion follows that the hypothesis is erroneous.

This conclusion directly contradicts the explanation of the phenomenon of aberration which has been hitherto generally accepted, and which presupposes that the earth moves through the ether, the latter remaining at rest.

It may not be out of place to add an extract from an article published in the Philosophical Magazine by Stokes in 1846.

"All these results would follow immediately from the theory of aberration which I proposed in the July number of this magazine: nor have I been able to obtain any result admitting of being compared with experiment, which would be different according to which theory we adopted. This affords a curious instance of two totally different theories running parallel to each other in the explanation of phenomena. I do not suppose that many would be disposed to maintain Fresnel's theory, when it is shown that it may be dispensed with, inasmuch as we would not be disposed to believe, without good evidence, that the ether moved quite freely through the solid mass of the earth. Still it would have been satisfactory, if it had been possible to have put the two theories to the test of some decisive experiment."

In conclusion, I take this opportunity to thank Mr. A. Graham Bell, who has provided the means for carrying out this work, and Professor Vogel, the Director of the *Astrophysicalisches Observatorium*, for his courtesy in placing the resources of his laboratory at my disposal.

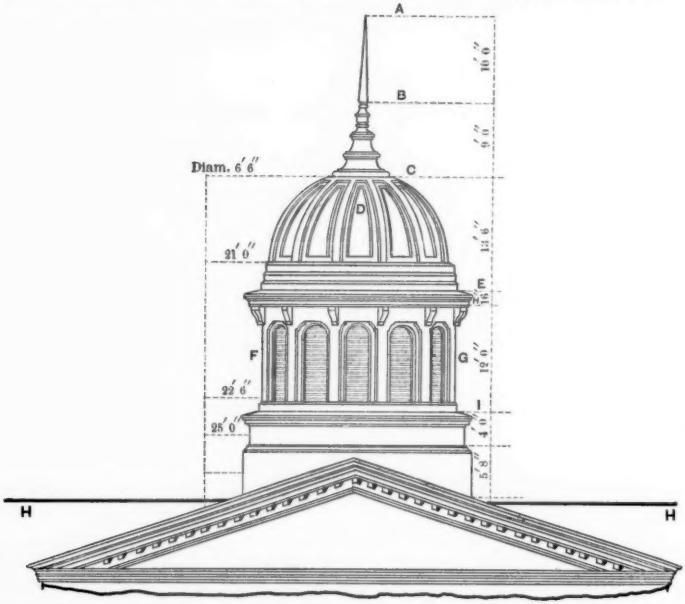
Art. XXII.—*Observations on the Light of Telescopes used as Night-Glasses;* by Edward S. Holden.

In the Philosophical Transactions for 1800, vol. xc, p. 67, Sir William Herschel says: "In the year 1776, when I had erected a telescope of 20 feet focal length, of the Newtonian construction, one of its effects by trial was that when toward evening, on account of darkness, the natural eye could not penetrate far into space, the telescope possessed that power sufficiently to show, by the dial of a distant church steeple, what o'clock it was, notwithstanding the naked eye could no longer see the steeple itself. Here I only speak of the penetrating power, for though it might require magnifying power to see the figures on the dial, it could require none to see the steeple."

I had long been desirous of trying this experiment with a large aperture, and made several attempts in 1874 to have the Dome of the 26 inch Clark refractor at Washington so arranged that a terrestrial object could be seen, but without success. I therefore took the first opportunity to try the effect of a telescope under these conditions at the Washburn Observatory, where the large equatorial commands the horizon. The most suitable object for examination was the tower of the Hospital

for the Insane, which is 20,798 feet distant from the center of the Dome.* 1″ at this distance is 1·3 inches; 1′ is 78 inches.

The accompanying figure will give the best idea of the object viewed. The drawing has been kindly made for me by W. V. Shipman, Esq., of Chicago. I have marked upon the cut the line of the horizon, from which it appears that the



whole tower has an elevation of about 9′ above the horizon line. In the observations which follow, the part A B, (10 feet high), is spoken of as "the spire;" B C, (9 feet), as "the base of the spire;" the next section, (13 feet high), as "the cupola" or "the dome," and the remaining portion, as "the tower."

The finder has an aperture of 3·50 inches, a field of 1° 20′, and a magnifying power of 26 diameters. The refractor has an aperture of 15·56 inches, a field of 11′·6, and a power of 195 diameters.

The following observations were made 1881, April 18, by Mr. S. W. Burnham and myself:

The whole sky was perfectly clear except a very faint bank of clouds to the west of the tower looked at. The observations were as follows: *Hn.* standing for observations made by Holden; *β* for those made by Burnham.

* I have to express my thanks to Professor J. E. Davies for the communication of the Coast Survey data from which these figures are derived.

$7^h\ 35^m$. The tower disappears to the naked eye. In the finder the spire is still plainly seen. In the 15-inch, the whole of the spire, ribs, dome and many details well seen.—*Hn.*

$7^h\ 42^m$. The tower disappears to the naked eye. In the finder and telescope everything still seen.—*β.*

$8^h\ 0^m$. 15-inch: the ribs on the cupola are gone.—*Hn.* and *β.*

$8^h\ 7^m$. Finder: the shape of the cupola is confused and uncertain.—*Hn.* and *β.*

$8^h\ 14^m$. Finder: pretty much the same. 15-inch: the spire on top of the cupola is still plain. No one looking with the telescope would miss it.—*Hn.* and *β.*

$8^h\ 17^m$. 15-inch: the spire on top of the cupola gone.—*Hn.* I still see it.—*β.*

$8^h\ 17^m$. Finder: all shape to the cupola is gone.—*Hn.*

$8^h\ 21^m$. 15-inch: spire still seen by averted vision; not well by direct.—*β.*

$8^h\ 22^m$. Finder: the tower is a mere black spot. 15-inch: spire is much fainter.—*β.*

$8^h\ 23^m$. 15-inch: the spire is gone, except that I can see that the outline of the cupola is not round.—*β.*

$8^h\ 25^m$. 15-inch: spire gone.—*β.*

$8^h\ 26^m$. Finder: tower gone.—*Hn.*

$8^h\ 27^m$. Finder: tower and cupola gone.—*β.*

$8^h\ 27^m$. 15-inch: tower and cupola gone.—*Hn.*

$8^h\ 29^m$. 15-inch: tower has lost all shape.—*β.*

$8^h\ 30^m$. 15-inch: tower gone.—*β.*

About this time the sky was dark and the horizon became clearer as was shown by small stars becoming visible in the finder. Probably the light cloud above spoken of was dissipated.

$8^h\ 35^m$. 15-inch: the cupola and tower can be plainly seen as a dusky cloud with a certain shape, when the telescope is vibrated to and fro.—*Hn.* and *β.*

$8^h\ 37^m$. 15-inch: same.—*Hn.* and *β.*

$8^h\ 43^m$. 15-inch: the cupola and tower are seen even better than before. The horizon is clearer. There is no difficulty in seeing them when the telescope is moved, and they can just be seen by direct vision.—*β.*

$8^h\ 44^m$. Same.—*Hn.* and *β.*

$8^h\ 45^m$. Stopped examination as there seemed to be no prospect of losing the tower as long as the horizon remained clear. If we had lost it we should have attributed the loss to haze at the horizon. Small stars 8-9 magnitude seen in finder. They must have had an altitude of not more than 30′.

It appears to me that this confirmation of Herschel's experiments is important, and worth the attention of physicists. So far as I know there is no satisfactory explanation of the action of the ordinary Night-glass, nor of the similar effect when large apertures are used.

Washburn Observatory, Madison, 1881, May 1.

ART. XXIII.—*On the nature of Dictyophyton;* by R. P. WHITFIELD. With a note, by J. W. DAWSON.

SINCE writing the article on *Dictyophyton* published in the last number of this Journal I have obtained additional evidence of their spongoid character. About the middle of May, while discussing their nature with Principal Dawson, of Montreal, we examined some allied forms from the Keokuk beds at Crawfordsville, Indiana, which lately came into the possession of the American Museum of Natural History, and found one which retained the substance of the organism. Under a hand-glass of moderate power it is seen to have been composed of cylindrical threads of various sizes, now replaced by pyrite. With the means then at our command it was impossible to fully determine whether they had been bundles of vegetable fibers or sponge-like spicules; but Dr. Dawson kindly offered to examine them more critically if I would forward a specimen to him at Montreal. This was done, and his note on their nature is appended below. The specimen used probably belongs to the genus *Uphantaenia* Vanuxem, and is a fragment about $2\frac{1}{2}$ by 3 inches across and seems to have been a part of a circular or discoid frond of 8 or 10 inches diameter. It differs from *Uphantaenia Chemungensis* of New York in many features. The broad, radiating bands are more distant, with a narrow, thread-like band between; while all the circular bands have been narrow or thread-like. The spaces between the bands and threads are rectangular and covered by a thin film which is alternately elevated or depressed in the adjoining spaces, as if the bands had been elastic like rubber and had contracted, wrinkling up the intermediate spaces. A further description and illustration of the form I shall defer to a future occasion, but shall here designate the species as *Uphantaenia Dawsoni.* The broad bands are composed of very fine thread-like spicules, and the narrow ones of much stronger ones, while the thin film occupying the intermediate spaces is composed of still smaller spicules apparently arranged in radiating manner. The character and nature of these threads and spicules are well set forth in Dr. Dawson's notes below, and the spongoid features and relations to *Euplectella* indicated.

Note by Dr. J. W. DAWSON *on the Structure of a specimen of Uphantaenia, from the Collection of the American Museum of Natural History, New York City.*

To the naked eye the fossil presents rectangular meshes of dark matter on a gray finely arenaceous matrix. The spaces of the network are of an average size of 6^{mm} in length and 4 or 5

in breadth. The longitudinal bands are about 3^{mm} broad, the transverse bands much narrower. Some of the rectangular interspaces are of the color of the matrix; others wholly or partially stained with dark matter. The meshes are nearly black, but in a bright light show a fibrous texture and metallic luster due to pyrite.

Viewed as opaque objects under the microscope, the reticulating bands are seen to be fascicles of slender cylindrical rods or spicules, varying much in diameter; some of the largest being in the narrow transverse bands. The spicules may, in a few cases, be seen to be tapering very gently to a point, but usually seem quite cylindrical and smooth. In their present state they appear as solid shining rods of pyrite. The largest spicules are about $\frac{1}{56}$ of an inch in diameter; the smaller scarcely one-fourth of that size. The spicules of the transverse bands cross those of the longitudinal ones without any organic connection. Among the long spicules of the bands can be seen multitudes of very minute and apparently short spicules confusedly disposed, and these abound also in the dark-colored areoles.

On the whole the structures are not identical with those of any plant known to me, and rather resemble those of siliceous sponges of the genus *Euplectella*.

The most puzzling fact in connection with this view is the mineral condition of the spicules now wholly replaced by pyrite. Carbonaceous structures are often replaced in this way and so are also calcareous shells, especially when they contain much corneous matter, but such changes are not usual with siliceous organisms. If the spicules were originally siliceous, either they must have had large internal cavities which have been filled with pyrite, or the original material must have been wholly dissolved out and its place occupied with pyrite. It is to be observed, however, that in fossil sponges the siliceous matter has not infrequently been dissolved out, and its space left vacant or filled with other matters. I have specimens of *Actylospongia* from the Niagara formation which have thus been replaced by matter of a ferruginous color; and in a bundle of fibers probably of a sponge allied to *Hyalonema* from the Upper Llandeilo of Scotland, I find the substance of the spicules entirely gone and the spaces formerly occupied by them empty. It should be added that joints of Crinoid stems and fronds of *Fenestella* occurring in the same specimen with the *Uphantaenia* are apparently in their natural calcareous state.

Though I have hitherto regarded this curious organism as a fucoid, I confess that the study of the specimen above referred to inclines me to regard it as more probably a sponge.

I owe the opportunity of examining this very interesting specimen to the kindness of Professor Whitfield.

ART. XXIV.—*Note on Photographs of the Spectrum of the Comet of June*, 1881; by Professor HENRY DRAPER, M.D.

THE appearance of a large comet has afforded an opportunity of adding to our knowledge of these bodies by applying to it a new means of research. Owing to the recent progress in photography, it was to be hoped that photographs of the comet and even of its spectrum might be obtained and peculiarities invisible to the eye detected. For such experiments my observatory was prepared, because for many years its resources had been directed to the more delicate branches of celestial photography and spectroscopy, such as photography of stellar spectra and of the nebulæ. More than a hundred photographs of spectra of stars have been taken, and in the nebula of Orion details equal in faintness to stars of the 14·7 magnitude have been photographed.

It was obvious that if the comet could be photographed by less than an hour's exposure, there would be a chance of obtaining a photograph of the spectrum of the coma, especially as it was probable that its ultra-violet region consisted of but few lines. In examining my photographs of the spectrum of the voltaic arc, a strong band or group of lines was found above H, and on the hypothesis that the incandescent vapor of a carbon compound exists in comets this band might be photographed in their spectrum.

Accordingly, at the first attempt, a photograph of the nucleus and part of the envelopes was obtained in seventeen minutes on the night of June 24th, through breaks in the clouds. On succeeding occasions, when an exposure of 162 minutes was given, the tail impressed itself to an extent of nearly ten degrees in length.

I next tried by interposing a direct vision prism between the sensitive plate and object glass to secure a photograph which would show the continuous spectrum of the nucleus and the banded spectrum of the coma. After an exposure of eighty-three minutes, a strong picture of the spectrum of the nucleus, coma and part of the tail was obtained, but the banded spectrum was overpowered by the continuous spectrum.

I then applied the two-prism spectroscope used for stellar spectrum photography, anticipating that although the diminution of light would be serious after passing through the slit, two prisms and two object glasses, yet the advantage of being able to have a juxtaposed comparison spectrum would make the attempt desirable, and moreover, the continuous spectrum being more weakened than the banded by the increased dispersion the latter would become more distinct.

Three photographs of the comet's spectrum have been taken with this arrangement with exposures of 180 minutes, 196 minutes and 228 minutes, and with a comparison spectrum on each. The continuous spectrum of the nucleus was plainly seen while the photography was in progress. It will take some time to reduce and discuss these photographs and prepare the auxiliary photographs which will be necessary for their interpretation. For the present it will suffice to say that the most striking feature is a heavy band above H which is divisible into lines, and in addition two faint bands, one between G and *h* and another between *h* and H. I was very careful to stop these exposures before dawn, fearing that the spectrum of daylight might become superposed on the cometary spectrum.

It would seem that these photographs strengthen the hypothesis of the presence of carbon in comets; but a series of comparisons will be necessary, and it is not improbable that a part of the spectrum may be due to other elements.

271 Madison Avenue, New York.

Art. XXV.—*Spectroscopic Observations upon the Comet b*, 1881; by Professor C. A. Young.

While the Comet was brightest the weather at Princeton was very tantalizing. From June 25 to July 3, the comet was seen and observed on every night except June 30, and on none of them, except July 2, more than an hour at a time, the work being invariably interrupted by clouds or fog.

For the spectroscopic observations I have used both the one-prism instrument, by the Clarks, which belongs with the Equatorial, and the solar spectroscope by Grubb—the latter with dispersive powers varying, according to occasion, from two to six dense glass prisms. The telescope was the 9½ inch Equatorial.

The following are the principal facts made out so far:

(1.) The spectrum of the nucleus was found to be for the most part simply continuous; but on several occasions, especially June 25, July 1, and July 12, it showed distinct bands, coinciding with those of the spectrum of the coma. When brightest the spectrum could easily be followed from the neighborhood of B to a point well above G; and in the lower portion it showed color strongly.

(2.) The spectrum of one of the jets which issue from the nucleus was isolated on June 29th and found to be continuous. I think this was usually the case with the jets, but it is seldom possible to separate the spectrum of a jet from that of the nucleus sufficiently to be perfectly sure.

(3.) The spectrum of the tail appears to be a continuous spectrum overlaid by a banded spectrum, the same as that of the coma. The bands in the spectrum of the tail were followed to a distance of about 20′ from the head, on June 29 and July 1. The continuous spectrum ceased to be visible before the bands were entirely lost sight of, using a slit wide enough to unite the *b's* into one band.

(4.) The spectrum of the coma shows only three bright bands with a faint continuous spectrum connecting them. No other bands could be found, though the continuous spectrum could be followed from about half way between C and D, to above G. The Fraunhofer lines could not be seen either in the spectra of the nucleus or of the coma.

While the comet was brightest, the bands, especially the upper and lower ones, were very ill-defined, so much so as to interfere with satisfactory measurements of position. After July 1 the definition became better.

(5.) The coma spectrum was very carefully compared with the spectrum of the Bunsen burner flame, with the spectra of Geissler tubes containing CO, CO_2 and ether vapor, and also with the spark spectrum of magnesium and air. The wave length of the less refrangible edges of each of the three bands was carefully determined by micrometer measures, on June 29, and on July 1, 2, 3, 6 and 12.

All the comparisons concur in showing a close, and so far as the dispersive power employed could decide, an *exact* agreement between the spectrum of the comet and that of the Bunsen flame. On the other hand the discordance between the comet-spectrum and the spectra of the Geissler tubes was striking. The lower of the three comet bands was the only one which was even approximately coincident with any band of the tube spectrum.

(6.) The measurements on the evenings named give the following numbers for the wave-lengths of the bands, viz:

Lower edge of lower band,	$\lambda = 5629{\cdot}$	$\pm 4{\cdot}0$
Lower edge of middle band,	$\lambda = 5164{\cdot}9$	$\pm 0{\cdot}6$
Lower edge of upper band,	$\lambda = 4740{\cdot}$	$\pm 2{\cdot}9$

The lower band was much the most difficult to deal with. The maximum of brightness seems to be, not at the edge of the band, but a little way up, and this perhaps may explain the fact that I obtained 5564 in the case of Winnecke's comet (while Von Konkoly obtained 5610—a much better result). Dr. Watts (Nature, vol. xx, page 28) gives 5634·7, 5165·3 and 4739·8 as the wave-lengths for the corresponding bands in the spectrum of the Bunsen flame.

(7.) The middle band, on June 29, July 1, 2, and 3, showed

three fine, bright lines upon it, one just at the lower edge of the band, and the other two at distances of about 30 Ångstrom units—coinciding apparently with three lines which are seen in the Bunsen flame spectrum, though I did not succeed in measuring them.

It is hardly necessary to say that the evidence as to the identity of the flame and comet spectra is almost overwhelming; the peculiar ill-defined appearance of the cometary bands at the time of the comet's greatest brightness is, however, something which I have not yet succeeded in imitating with the flame spectrum. The comet spectrum on July 25th certainly presented a general appearance quite different from that of the later observations, as regards the definition of the bands.

Perhaps I may be allowed to record here a fact which has nothing to do with the comet, but was observed while adjusting the spectroscopes upon the sun in preparation for evening work. I find that the one-prism spectroscope shows the bright lines in the upper portion of the chromosphere spectrum, above *h*, better than any other instrument I have yet tried. I have hitherto always found it rather difficult to exhibit the two H's as bright lines to a person unused to the spectroscope, but with this instrument they are perfectly obvious—even obtrusive. The only (and indispensable) precaution needed is to put the slit accurately in the focal plane of the telescope for these special rays.

Princeton, July 14.

ART. XXVI.—*Note on the Observations of Comet b*, 1881, *made at the United States Naval Observatory;* by WM. HARKNESS.

[Communicated by authority of Rear Admiral John Rodgers, U. S. N., Superintendent.]

ON the evening of June 28th, I examined the comet for polarization by means of a double image prism applied to the naked eye, and at first I fancied that when the two images were placed in the axis of the tail the one situated farthest forward was the fainter, but a careful examination by three different observers rendered this doubtful. Recourse was then had to a three-inch telescope armed with an eye-piece magnifying 34·5 diameters, and the image of the comet given by it was examined, first with the double image prism, and subsequently with a Savart polariscope, but neither of these instruments showed any polarization. Mr. Huggins thinks he has detected the

Fraunhofer lines in the continuous spectrum of the nucleus, and if this really is the case its light must be at least partly derived from the sun, and should show traces of polarization. As just stated, I failed to discern any with the double image prism; but that is not a very delicate test, although, owing to the small size of the nucleus, it is almost the only one practicable. Under the magnifying power used the coma filled the field of view with bright light, and yet exhibited not a trace of polarization when tried by that most delicate of all tests, the Savart polariscope; thus apparently confirming the testimony of the spectroscope that the coma is self-luminous.

On the evenings of June 28th, and July 1st and 2d, I examined the spectrum of the comet with a spectroscope having a single sixty-degree prism through which a beam of light 0·82 of an inch in diameter is passed. The wave-lengths of the bands in the comet's spectrum were determined by measuring the interval between them and the D line given by the flame of a spirit lamp with a salted wick held before the object glass of the telescope to which the spectroscope was attached; the measurement being effected by a micrometer which showed a bright point in the field of view. Owing to the unfavorable position of the comet, the only telescope upon which the spectroscope could be used was my three inch of 43·6 inches focus, which is mounted upon a portable tripod stand, but is destitute of clamp and tangent screws.

Notwithstanding the brightness of the comet, it gave a spectrum very ill-defined, and difficult to measure. The spectrum of the nucleus seemed to be continuous, and its approximate extent was from D to G. I did not detect any Fraunhofer lines in it, but possibly they may exist and yet have been obliterated by the rather wide opening of the slit, which was 0·0125 of an inch. With a narrower slit it was difficult to keep the comet in the field of the spectroscope. The coma gave a spectrum consisting of three bright bands, so ill-defined that no precise measures of the wave-lengths of their edges could be made, but the wave-lengths of their brightest parts were respectively, 549·3, 512·4 and 467·2. This seems to be the ordinary comet spectrum. The measurement of the wave-length of the middle band is tolerably accurate, but the measurements of the other two are liable to considerable uncertainty, owing to the faintness of the bands. I estimated their relative brightness to be 5, 30 and 1. On July 1st a slight haziness of the atmosphere sufficed to render the third band invisible. At a short distance from the head of the comet this band always faded out, and the spectrum of the tail seemed to consist of the first and second bands only—that is 549·3 and 512·4.

On June 28th the comet's nucleus was about as bright as a third-magnitude star, and its tail was plainly visible throughout an extent of at least twelve degrees. On July 1st the comet was perceptibly fainter, and its tail was only about eight degrees long, but perhaps this was partly owing to the moon, five and a half days old, being above the horizon. On July 2d the atmosphere was very clear and the seeing good, but the visibility of the comet was much diminished by the brightness of the moon, then near its first quarter. I estimated the length of the tail to be about the same as on the preceding evening, but Mr. Rock thought he could trace it for rather more than twenty degrees.

Since the 10th inst., Professor Hall has examined the comet with the twenty-six inch refractor, and Professor Eastman has examined it with the nine and six-tenth inch refractor, but neither of these gentlemen have been able to see any indications of a division of the nucleus.

The comet was observed at its lower culmination, with the transit circle, on June 26, 27, 28, 29 and July 1, 2, 3, 5, 6, 10, 11. For the convenience of those who may desire to compute the orbit, Professor Eastman has furnished from these observations, the following positions, which are uncorrected for parallax and aberration time:

Washington Date.	Right Ascension.	Declination.
June 26·5	$5^h\ 48^m\ 38^s{\cdot}04$	$+57°\ 40'\ 52''{\cdot}0$
July 1·5	6 22 46 ·85	70 39 57 ·6
" 3·5	6 42 32 ·92	74 5 16 ·2
" 6·5	7 20 36 ·88	77 49 56 ·3
" 10·5	8 27 31 ·84	+80 48 56 ·1

From a Cambridge observation of June 23d, and the Washington observations of June 29th and July 5th, Professor Frisby has computed the following parabolic elements:

Perihelion Time, June 16·3700

$\pi = 265°\ 31'\ 15''{\cdot}4$
$\Omega = 270\ 58\ 27\ {\cdot}0$ } Equinox 1881·0
$i = 63°\ 25'\ 55''{\cdot}7$
$\log q = 9{\cdot}866748$

The residuals, C−O, for the middle place are

$$\delta\lambda \cos\beta = -13''{\cdot}4$$
$$\delta\beta = +62\ {\cdot}1$$

It is a matter of interest to note that about June 20th the earth was in the immediate vicinity of the comet's tail, but I have not made sufficiently accurate computations to be able to state whether or not it actually passed through it.

U. S. Naval Observatory, Washington, July 13, 1881.

Art. XXVII.—*Observations on the Comet* 1881 *b*; by Lewis Boss.

News of the sudden appearance of a great comet in the northern sky first reached me through the local newspapers on June 23; but that night was cloudy. On the evening of June 24, the comet was occasionally seen for a few moments at a time, through intervals in clouds, but never with sufficient clearness to admit of satisfactory examinations as to its physical appearance. One micrometric comparison between the comet and DM 50° 1225 was secured with the thirteen-inch refractor. The comet was plainly visible to unassisted vision in a clear sky at sixteen hours mean time, and then appeared as bright as Capella.

Owing to an accident which happened to the equatorial during my absence, I have thus far been unable to secure additional micrometric comparison by that instrument. At lower culmination the comet has usually been hidden by clouds, and the hour is now very inconvenient; so that I can report only the following observations of apparent position:

D. O. M. T.	App. α.	App. δ.	
June 24^d 9^h 59^m 31^s	5^h 39^m $14^s{\cdot}2$	$+49°$ $59'$ $20''{\cdot}$	Filar micrometer.*
June 26 11 26 51	5 48 35·53	+ 57 39 05·2	Transit circle.
June 28 11 30 26	6 00 00·69	+ 63 43 31·8	Transit circle.
July 8 12 42 38	7 51 49·54	+ 79 34 03·0	Transit circle.

From the first three positions reduced to 1881·0 and corrected for parallax and aberration by means of values of Δ from a preliminary orbit, I derived the following parabolic elements.

T = 1881, June 16·1358. Washington M. T.

$$\left.\begin{array}{ll} \pi & 265°\ 01'\ 38'' \\ \Omega & 270\ 58\ 45 \\ i & 63\ 30\ 27 \end{array}\right\} 1881{\cdot}0$$

$\log q$ 9·86510

Middle place, C−O. $\Delta\lambda \cos\beta$, $+4''$. $\Delta\beta$, $-7''$. We also have with the same elements: July 8, C−O. $\Delta\lambda \cos\beta$, $+30''$. $\Delta\beta$, $-75''$. The elements therefore are not likely to be found greatly in error.

The similarity of the elements of this comet with those deduced by various computers for the comet of 1807, has already been much discussed in the newspapers. The difference of about three degrees in the position of the nodes, and especially the great difference in the respective values of q (which amounts to ·087) seems larger than can well be ascribed to errors of computation, or possible planetary disturbance.

* Star of comparison DM 50° 1225, position obtained from Argelander's northern zones combined with Bonn VI. $\Delta\alpha$ on three wires; $\Delta\delta$, one measure.

It seems to me more likely that these two comets may have formed parts of the same body in distant ages, and that these parts may have separated as Biela's comet did. The two parts would need to have but slightly differing mean distances from the sun in order eventually to reach the amount of separation which now exists between the perihelion passages of the 1807 and 1881 comets. A great number of similar, though generally less striking resemblances among cometic orbits have been noted, in cases where absolute identity between the two comets considered seems impossible. These cases increase the demand for a general explanation, such as I have suggested above. The resemblances seem to be too close and too frequent to be considered the result of chance; and the above hypothesis seems to have some support in reason and experience. If the comet of 1881 proves to have a periodic time between one and two thousand years the plausibility of this hypothesis will be very much strengthened.

I have been too much pressed with other duties to give close or systematic attention to the physical characteristics of the comet. The nights of June 26, June 28, July 1, 8 and 13 were unusually favorable for such studies here. The atmosphere was unusually transparent on June 26 and I then traced the tail for a distance of nearly forty degrees from the nucleus. On that night there were two branches. The longer and brighter branch was perfectly straight. The other curved, with its concavity toward greater right ascension. On the next clear night (June 28) the straight branch was of about the same length as the curved one, and was a thin and scarcely perceptible streak. On July 1, the two branches seem to have merged into one, presenting a shorter and broad fan-like appendage, perfectly straight and strongly marked on the preceding side, concave and nebulous on the following.

On all occasions the nucleus under a power of 250 has seemed to be quite distinctly defined and star-like in appearance. On June 26, its measured diameter was $7''$; on July 8, this had become $2''$. The latter measure reduced to the distance of June 26 becomes $3''{\cdot}3$, a rather surprising reduction in the diameter, if it be real.

Dudley Observatory, Albany, N. Y., July 19, 1881.

Art. XXVIII.—*The Polarization of Light from Comet b*, 1881; by Arthur W. Wright.

Polariscopic observations of the comet were made on the evenings of June 25 and 26, which gave faint indications of the existence of polarization, but with the instruments then used it was not possible to ascertain satisfactorily either its character or amount. The state of the sky was not very favorable for observation until the evening of June 29, when a method of observation was found which made it possible to determine the polarization, which was at once seen to be considerable, with comparative ease and a good degree of precision.

The instrument employed was the polarimeter constructed for observation of the solar corona in the eclipse of July 29, 1878, and described in the volume containing the reports upon this eclipse issued from the U. S. Naval Observatory.* A slight modification was made by substituting a Savart plate for the selenite, it being attached to the Nicol's prism in the eye-piece. This gave a rather narrow field which was nearly filled by the image of the comet, an arrangement very favorable for detection of the bands caused by polarization. The aperture of the telescope to which the polarimeter is attached is three inches.

The plane of polarization of the light was found to have such a direction as to pass through the sun's place. This was determined both by the disposition of the bands seen in the polarimeter, and also independently by means of a double-image prism placed before the ordinary eye-piece of the telescope when this was attached to the instrument. The two images of the comet as the prism was rotated were easily seen to have different intensities in certain positions corresponding to polarization in a plane situated as above described. As seen with this instrument the fainter of the images appeared considerably shorter than the other as if the light coming from toward the extremity of the tail were more strongly polarized than that from points near the nucleus. But this was possibly an illusion depending upon the fact that when the very faint light was diminished by the polarizing effect it became too feeble for perception, and this lessened the extent of the visible area. When examined with the polarimeter the light appeared to be slightly less strongly polarized as the instrument was directed to points more remote from the head of the comet, as would be the case if the proportion depended simply upon the angle of incidence of the light, which decreased with the distance from

* Reports on the Total Solar Eclipses of July 29, 1878, and January 11, 1880, pp. 264–267.

the nucleus. The second and third of the observations of July 1, in the list below, were made upon regions removed several degrees from the nucleus, but though the amount of polarization is somewhat less, and tends to confirm the above conclusion, the difference is hardly greater than would be accounted for by the errors of observation. Determinations of polarization at great distances from the nucleus were not possible, the light being too feeble.

In the use of the polarimeter, the latter was fitted so that a card could be attached to the slide moving the glass plates. The positions were pricked upon this with a needle point, and were read off by means of the graduated circle after the observations were finished. The latter were made in sets of ten, the plates being moved to the point of neutralization, or disappearance of the bands, first from below, then from above, alternately, until five had been made from each direction. The points upon the card thus fell into two groups separated by an interval which was greater or less according to the degree of polarization. The mean of the angles for each set of five being taken, the percentage of polarized light corresponding to each was determined from a curve constructed for the instrument. Two values were thus obtained the mean of which was the amount of polarization for the point observed. Each card was capable of containing two sets of points, and could be removed or replaced by another without the aid of a light, a necessary precaution in observations of such delicacy, as the proper sensitiveness of the eye could only be maintained by seclusion from the light.

The results of the observation are given in the following table. The date and local mean time for the series of each evening are given in column I. In column II are given the results derived from the sets of determinations arranged in their order as made, each result, as explained above, being obtained by ten measurements. The numbers express the proportion of polarized light to the total light reckoned as one hundred parts. The means of the percentages of the sets in column II for each evening are given in column III. Column IV gives the approximate angles of incidence of the light derived from the sun, referred to the nucleus or points very near it. It is obtained from the ephemeris of Peters,* combined with that of Oppenheim given in the Dun Echt Circular No. 24. The angles subtended at the comet by the earth's radius vector at the dates of the ephemeris were obtained by a simple graphic process. With these a curve was constructed from which the angles for the dates of the different observations were derived. These divided by two are the angles of incidence.

* Astronomische Nachrichten, No. 2381, p. 75.

I.	II.	III.	IV.
June 29, 1^h to 2^h, A. M.	24·7 23·8 21·3	23·3	60°·5
June 30, 1^h to 2^h, A. M.	18·1 17·6 18·6 17·1	17·8	58°
July 1, 11^h to 12^h 30^m P. M.	21·8 20·1 17·6 17·7	19·3	54°·5
July 2, 10^h 30^m to 11^h P. M.	16·9 16·9	16·9	52°·5
July 3, 10^h 30^m to 12^h P. M.	18·3 18·0 18·7	18·3	51°
July 21, 11^h 30^m P. M. to 1^h.	15·9 15·6	15·7	33°
July 22, 11^h 30^m P. M. to 1^h.	14·5 13·8	14·1	32°

The observation of July 2 was made under rather unfavorable atmospheric conditions, and the sky was somewhat luminous from auroral action. The amount of polarization found is undoubtedly less than the true value. The others were made when the sky was very clear, and during those of July 21 and 22 it was exceptionally fine. The time of the observations precluded the possibility of any influence from twilight or the light of the moon.

On comparing the percentage of light polarized and the angles of incidence it is seen that they decrease together. No definite maximum was made out, but the existence of one near or beyond 60° is perhaps indicated by the fact that polarization was less easily observed on the evenings previous to June 29, and by the more rapid variation in the percentages on this and the two succeeding evenings. At first sight the large percentages obtained in the earlier observations appeared to indicate reflection from a gaseous substance, but the numbers found later, and especially the relation of all the values to the angles of incidence, render an inference as to the character of the reflecting material more difficult. It is not improbable that the constitution and physical condition of the matter composing the tail were variable, and this circumstance would introduce changes in the proportion of polarized light, in addition to those produced by the alteration in the angle of the reflected rays. The fact of polarization shows that a large part, probably the greater part, of the light coming from the tail is reflected sunlight.

Yale College, July 25, 1881.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Ozone as a cause of the Luminosity of Phosphorus.*—Various writers, especially Joubert, have called attention to the connection of the phenomena of phosphorescence with ozone. To learn something of the nature of this connection, Chappuis has studied the effect of ozone upon the luminosity of phosphorus in the presence of oxygen. Fourcroy had long ago observed that in pure oxygen at a temperature of 15° and under atmospheric pressure, phosphorus is not luminous in the dark. Chappuis now finds that under these conditions a bubble of ozone introduced into the bell jar produces the phosphorescence, though only momentarily, the ozone being destroyed. Moreover, it is not the vaporization of the phosphorus which determines the phosphorescence, but the combustion of this vapor, the entire space occupied by the oxygen at first appearing luminous, the solid becoming so only after all the vapor has been burned by the ozone. Two cylinders, one containing air, the other pure oxygen, were inverted over two dishes containing iodide of potassium and starch solution. A fragment of phosphorus was plunged into each gas, in contact with the liquid. In the first, the phosphorus became luminous and the solution became blue. In the second neither phenomena appeared. Whenever the phosphorescence appeared, ozone was present; and whenever ozone was absent there was no luminosity. Moreover, the author calls attention to the fact that certain bodies which have the power of preventing this luminosity of phosphorus are precisely those bodies which destroy ozone or are destroyed by it. Oil of turpentine for example, which is the most active, destroys ozone completely. In a balloon containing air, phosphorus and turpentine, a bubble of ozone produces light for a second only, the ozone being destroyed by the turpentine, but burning a part of the phosphorus vapor also. On adding the ozone the luminosity extends throughout the space and at last the solid phosphorus only remains luminous. Hence the author regards the production of the luminosity of phosphorus in oxygen, as one of the most delicate of the reactions for ozone and proposes to employ it in subsequent researches.—*Bull. Soc. Ch.*, II, xxxv, 419, April, 1881.

G. F. B.

2. *On the appearance of Nitrous Acid during the Evaporation of Water.*—Warington has submitted to the test of careful experiment Schönbein's statement that whenever pure water or an alkaline solution is evaporated, nitrite of ammonium is produced, and concludes that "it is undeniable that pure water if evaporated to a small bulk, by ordinary means, will generally be found to contain nitrous acid." A sample of rain water which gave no reaction to the metaphenylenediamine test, after concentration to one quarter of its bulk, showed the reaction distinctly. A liter of distilled water, with 5cc. lime water, evaporated to a small volume

over a Bunsen burner gave a strong reaction. The importance of this result, with reference to the determination of nitrites in natural waters, led to an investigation of the cause of this result. First it appeared that a liter of distilled water evaporated in a retort, either exhausted or at atmospheric pressure, gave no reaction for nitrous acid, and hence proved the air to be the source of the contamination. Another liter with 5cc. lime water, was evaporated in a glass basin 6¼ inches in diameter over a Bunsen rose burner. The reaction given was strong and corresponded to about 0·05 mgrm. of nitrogen. Since a second similar evaporation conducted with steam gave only 0·004 mgrm. nitrogen, it was clear that the nitrous acid had mainly come from the combustion of the gas used as fuel. But still even in the residue obtained with steam, the rose-color appeared. That this came directly from the air of the room was shown by placing a second basin of distilled water by the side of the first during the evaporation. After twenty-four hours a full rose tint was developed; and this without any sensible evaporation. For extremely accurate work, water then must be evaporated in close vessels; but for ordinary purposes, the concentration may be effected in a steam bath.

Warington gives in his paper some experiments made with the naphthylamine test for nitrous acid, proposed by Griess, which show an extraordinary delicacy. The solution to be tested was slightly acidified with hydrochloric acid and a few drops of an aqueous solution of sulphanilic acid and of a similar solution of naphthylamine hydrochloride were added. The nitrous acid if present forms a diazo-compound, which the naphthylamine converts into a body having a beautiful rose color. The tests for delicacy were made in test tubes, the column of liquid being about three inches deep. To 10cc. of the solution were added one drop of HCl (1 : 4) one drop of a nearly saturated solution of sulphanilic acid and one drop of a saturated solution of naphthylamine hydrochloride. The standard solution was made with potassium nitrite prepared from pure silver nitrite. With a solution of 1 part of nitrogen as nitrous acid in 1,000,000 parts of water an immediate pink color appeared which rapidly became deep ruby red; in 10,000,000 parts, at once a pink, and at the end of an hour a full rose; in 100,000,000 parts a pink tinge in six minutes and a pale pink in an hour; in 500,000,000 parts (1cc. of the millionth solution in a half liter of water) showed a pink tinge before two hours, and in twenty-four hours the three inch column showed it; 1,000,000,000 parts using ten drops of the reagents, showed an alteration of tint in two hours, and a distinct pink color in twenty-four hours. In the last two experiments similar flasks to which no nitrite had been added were similarly treated, but without result. During the reading of the paper in the Chemical Society's room, the presence of nitrous acid in the air was shown by exposing 200cc. of water containing the test, to the atmosphere there in a basin for four hours. On pouring it into a cylinder, it had become rose-pink as was seen on comparing it with a similar cylinder which had been closed with a

watch glass. In the open air at the Rothamsted farm, nitrous acid was detected by this air test. In six days the reaction appeared in water exposed to this air, and in twenty-seven days it contained one part of nitrogen in 15,000,000. In rain water the naphthylamine test readily shows nitrous acid, except when the rains are exceptionally heavy.—*J. Chem. Soc.*, xxxix, 229, May, 1881. G. F. B.

3. *On Boron hydride.*—Jones and Taylor have examined with care the preparation and properties of the boron hydride discovered by the former in 1879. Three methods of preparing magnesium boride were used: 1st, the action of recently ignited boric oxide, finely powdered, upon magnesium dust; 2d, the direct union of magnesium and boron; and 3d, the action of magnesium on boron trichloride. Though the two latter methods yielded a purer product, the first was the more convenient. The magnesium boride is placed in a flask with a little water and strong hydrochloric acid is added. The evolved gas may be collected over water or mercury. It is boron hydride mixed with a large quantity of hydrogen. In this condition it is a colorless gas which has an extremely disagreeable and characteristic odor, producing nausea and headache, is slightly soluble in water, which does not decompose it, burns with a splendid green flame, producing boric oxide, is decomposed by passage through a red-hot tube, depositing a brown film of boron, and depositing boron on a porcelain plate held in its flame, is decomposed when passed through a solution of silver nitrate giving a black precipitate containing boron and silver, and is oxidized to boric acid by potassium permanganate solution. With ammonia it gave a compound decomposed by acids. On analysis the boron appeared to be combined with 2·86 parts H; confirming the formula BH_3.—*J. Chem. Soc.*, xxxix, 213, May, 1881. G. F. B.

4. *On the Purification of Carbon Disulphide.*—Allary has proposed a simple, rapid and effective method of purifying carbon disulphide. This consists in covering it with a layer of water to which, from time to time, portions of a concentrated solution of potassium permanganate are added. The whole is strongly agitated after each addition, the process being stopped when the reduction of the permanganate is no longer produced, and the water retains its purple color. After washing several times, the disulphide is obtained free from water by means of a separating funnel, and filtered through a thick dry paper. Redistillation is seldom necessary. The odor is etherial and not at all disagreeable. It should be kept in the dark.—*Bull. Soc. Ch.*, II, xxxv, 491, May, 1881. G. F. B.

5. *Electric Absorption of Crystals.*—Professor H. A. Rowland and Mr. E. H. Nichols discuss the question whether there should be electric absorption in a perfectly homogeneous medium. The theory indicates that there should be none, and the writers have tested the point by experiment, and it was found that Iceland spar had no electric absorption. This substance can be

regarded as perfectly homogeneous. The writers consider that the apparatus which they used will be of value in testing the perfect homogeneity of insulating bodies.—*Phil. Mag.*, June, 1881, p. 414. J. T.

6. *Transmission of radiation of low refrangibility through Ebonite.*—Captain Abney and Colonel Festing have repeated the experiments of Professor Bell which showed that invisible rays of heat, of low refrangibility, pass through ebonite, by exposing a sensitive photographic plate to these radiations. An image was formed in many cases and the writers conclude that the coëfficient of absorption of a plate of ebonite $\frac{1}{64}$ of an inch in thickness is equal to 1·8 and that any rays which can penetrate through $\frac{1}{8}$ of an inch of ebonite will only have an intensity of $\frac{1}{16500000}$ of that of the resultant beam without deducting anything for the scattering of the light. It is concluded "that ebonite when of small thickness transmits to some extent the rays of low refrangibility."—*Phil. Mag.*, June, 1881, p. 466. J. T.

7. *Conservation of Electricity.*—M. G. Lippmann continues his paper on this subject—see *Comptes Rendus*, May 2, 1881—and maintains that the principle of the conservation of electricity stands in the same relation to electricity that Carnot's principle stands to heat.—*Comptes Rendus*, p. 1149, No. 20, May 16, 1881. J. T.

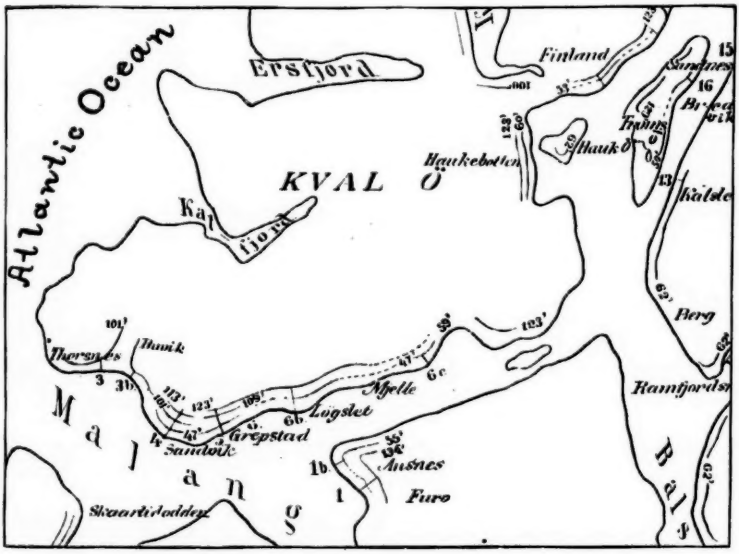
8. *Heating of Ice.*—A. Wüllner repeats the experiments of Carnelley and concludes that so long as the bulb of the thermometer is wholly surrounded with ice the thermometer indicates no temperature above —3° C. The thermometer with its bulb encased in ice was placed in an air-tight test tube, which was enlarged by a connecting tube of glass ending in a larger receptacle; the air contained in this could be raised or lowered in temperature and thus the temperature of the air in the test tube could be modified. When this air was heated by a Bunsen burner the thermometer rose quickly to −3° C. The ice vaporized quickly; when the bulb of the thermometer ceased to be completely surrounded by ice the temperature rose to 0° C., and when the thermometer bulb became more free from ice the temperature rose very quickly as the ice vaporized. Wüllner confirms the observation of Carnelley that the thermometer under these conditions could rise from 20° C. to 30° C. above zero and pieces of ice still be observed hanging to the thermometer bulb.—*Wied. Annalen der Physik und Chemie*, No. 5, 1881, p. 105. J. T.

9. *Atomic Weight of Cadmium.*—Mr. Oliver W. Huntington, of Harvard, has made a study of the atomic weight of cadmium, following the method used by Prof. Cooke with reference to antimony. The mean result from his first series of experiment is 112·31; and from a second, 112·32.

II. Geology and Mineralogy.

1. *Terraces and ancient Coast lines* ("*Strandlinien*"); by Karl Pettersen. Published in Norwegian, at Tromsö, in 1880, and translated into German by Dr. R. Lehmann, Zeitsch. f. d. gesammt. Naturwissenschaften, liii, 1880.—Prof. Pettersen has carried on an extended series of observations of the system of terraces in northern Norway. The region examined extends from north to south about 50 English miles and an equal distance from east to west, embracing the fiords and sounds in the neighborhood of Tromsö (lat. 70° N.). A portion (about one-fourth) of the map accompanying his article is reproduced in fig. 1, of the same scale as the original. The terrace system includes first the proper terraces of loose material, sand, gravel and so on, and secondly the "strandlinien" or coast lines which are worn out of the solid

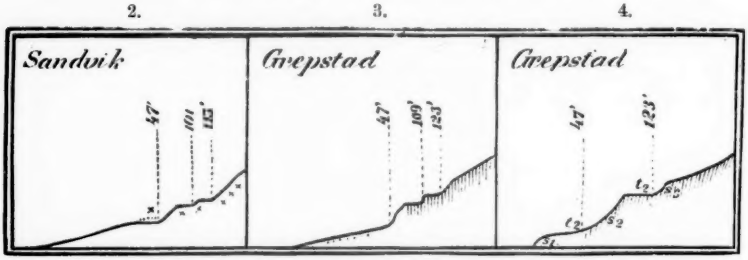
1.



rock. Each of them consists of two parts, the more or less level upper surface, and the slope which bounds it in front (see t_2 and s_1, s_2, s_3 in fig. 4). A survey of all the results of observation shows that these bench lines occur at almost every height from the lower limit up. Between the bench lines at 13·9 and 42·7 meters above the sea the average difference in height of any two successive lines is only 2·2 meters, while the maximum is never greater than 3·8; above the upper limit named the same may be true but the number of lines observed is smaller.

Figure 1 represents these several lines at the different points on

the coast near Tromsö, and figs. 2, 3, 4 give sections at three points (see also fig. 1), which may fairly be taken as typical. Figure 2 is from Sandvik, where are three levels, namely, 14·5, 31·6 and 35·4 meters above the mean sea surface (in the figures the heights are given in Norwegian feet); the lowest has a maximum breadth of 19 meters. Fig. 3 is a section at a point between Sandvik and Grepstad, where the three levels are 14·5, 34·1 and 38·5 meters. Fig. 4 represnts a section at Grepstad where there are only two levels, namely, 14·5 and 38·4 meters.



It is concluded, in the first place, that the terraces and "strandlinien" do not, taken as a whole, follow definite levels. Some of them are local and are observed only for short distances, while others extend along for many miles. The latter are more typically developed, are more connected with definite levels, and may be traced as such for long distances in Northern Norway. The formation of these was probably in part determined by periodic changes in climate. The course of any particular line is nearly horizontal, whether it runs parallel with the coast, or extends from the coast into the interior, although the highest levels are found in the interior of the fiords. The conclusion of Bravais (1842) that these lines are not horizontal but rather rise in level toward the interior, upon which the idea of a gradual secular elevation of the land, joined with an unchanged level of the sea, has been in part based is not accepted as generally true. That the wearing action of the sea has been the only cause in producing the results observed is not regarded as probable, and this conclusion is supported by several arguments; what other forces were instrumental in producing the result is not distinctly stated. The formation of the "strandlinier" must have begun at the upper edge of the downward slope and the excavation gone on from above down while the land rose slowly in reference to the surface of the sea. The apparent elevation of the land is regarded as having gone on gradually and slowly and not suddenly and interruptedly. In general these changes in level which went on along the coast of northern Norway during the post-glacial time are believed to be most easily explained by the supposition of a changing level of the sea.

2. *On the substances obtained from some "Forts vitrifiés" in France.*—M. Daubrée has made a critical mineralogical and

chemical examination of materials obtained from several "Forts vitrifiés" in different parts of France. This name is given to the walls or to the simple debris of walls, whose materials have been fused together by the action of fire.

The substance obtained from the neighborhood of Argentan was of a dark greenish brown color, opaque, and resembled certain slags. A section examined under the microscope revealed the presence of large numbers of crystals of an octahedral mineral, probably spinel, and also crystals of melilite, both formed by the process of fusion. An analysis showed a considerable amount of alumina and of soda, leading to the inference that the fusion had been accomplished by adding marine salt to the aluminous silicate in the clays and schists. Some partially fused granitic rocks from the forts of Château-vieux and of Puy de Gaudy (Creuse), also from the neigborhood of Saint Brieuc (Côtes-du-Nord), were especially examined. The specimens consisted of small fragments of the granite, some angular, others more or less rounded, and all forming a solid mass, with a glassy surface. They were in some cases similar in appearance to volcanic scoria.

When sections of the granite were examined in the microscope it was found that the orthoclase still acted upon polarized light, and the albite also was nearly unaltered, but besides them there were vitreous masses produced by the fusion. Of the minerals formed by the process, spinel was very common in regular octahedrons, sometimes transparent, sometimes opaque. There are also large numbers of microlites in geodes in the fused mica, which are probably to be referred to a triclinic feldspar. The small quantity of fluorine originally contained in the mica is regarded as having played an important part in the changes accompanying the fusion. These granites had been fused immediately by fire without the aid of soda, as in the first case named, and it is reasonably certain that the process of fusing together the small fragments was intentional although the means by which it was accomplished so thoroughly is less easy to understand.

3. *Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario.*—Mr. J. W. Spencer discusses this subject in a paper published in the Proceedings of the American Philosophical Society for 1881. He reaches the conclusion that a deep channel passed off from the southern part of Lake Huron along the course of the present valley of the Au Sable, pursued an east-southeast course and entered the basin of Lake Erie west of Vienna, bent around Long Island (east of Vienna), and then took a north-by-west course to Ancaster in the Province of Canada, whence it followed an easterly course along Dundas Valley into the west end of Lake Ontario; and that this channel was in preglacial time the outlet of Lake Erie into Lake Ontario. The supposed channel is now buried beneath drift. In the Dundas Valley (which is bounded by vertical escarpments) the drift has been penetrated to a depth of 227 feet below the surface of Lake Ontario. He also endeavors to show that the Great Lakes owe their existence to subaerial and

fluviatile agencies, but not to glacier excavation. The memoir is accompanied by two maps of the region.

4. *Laccoliths (or Laccolites) in Japan.*—Mr. G. H. Kinahan has described Laccolith-like intrusions of eruptive rocks in Counties Wexford and Wicklow, Ireland. They occur in highly disturbed Cambro-Silurian strata of different kinds, and the latter are baked or altered for some distance about them.—*Geol. Mag.*, March, 1881.

5. *Iron Ore of Iron Mine Hill, Cumberland, Rhode Island.*—Mr. M. E. Wadsworth describes this "titaniferous iron ore"—a titaniferous magnetite—as containing in its ground-mass large crystals of a triclinic feldspar along with *chrysolite* in grains, and mentions its resembling the Taberg iron ore rock of Sweden. Part of the chrysolite is changed to serpentine. An analysis of the ore by Prof. R. H. Thurston obtained 9·9 per cent of titanium. The rock nearest to the iron ore-bed is mica schist "some hundred feet away." Mr. Wadsworth supposes the iron ore to be of eruptive origin. (Mus. Comp. Zool., vol. vii (*Geol. Series, vol. I*).

It is of importance to note that a chrysolitic magnetite occurs at the O'Neil Mine, Monroe, Orange County, New York, the chrysolite of which was first determined and described by Prof. Brush, who gave it a distinctive name, hortonolite, on account of the amount of manganese present. As the iron ore deposits of Sussex County, New Jersey, and Orange County, New York, constitute *beds conformable to the adjoining schist*, and are, as Prof. G. H. Cook, of New Jersey, states, after extensive investigation, of metamorphic origin, it is probable that the Rhode Island magnetite is also metamorphic. J. D. D.

6. *Brazos Coal-field, Texas.*—A paper on this Texas coal-field, by C. A. Ashburner, is published in the Transactions of the American Institute of Mining Engineers, for 1881. The coal field proper in the southwestern part of the "Missourian or Fourth bituminous coal-basin of the United States" in which are two workable beds 2½ to 6 feet, are 85 feet thick, and are included between an upper sandstone and conglomerate, representative of the Millstone grit or Pottsville conglomerate (No. XII of the Pennsylvania series), and a lower gray limestone representative of the Mountain limestone, or Chester and St. Louis limestone, of the Mississippi Valley.

7. *Report of the Geological Survey of Pennsylvania, on the causes, kinds and amount of waste in mining Anthracite* (numbered A2), by Franklin Platt; with a chapter on the Methods of Mining, by J. P. Wetherell. 134 pp. 8vo, with thirty-five figures of mining operations, a plan of an anthracite breaker, also a specimen sheet of the work of the survey in the Anthracite Coal Field.—The specimen sheet of the anthracite coal-field, appended to this very important and well illustrated report, is by C. A. Ashburner. It contains a section on a large scale, exhibiting the stratification and flexures of the beds, and also a corresponding ground plan or map view, giving the topographical features of the

region, and the actual positions and structure of the several "veins" (beds), as explored.

Mr. Ashburner, in a paper read before the American Institute of Mining Engineers, states that his plan includes the exhibition on the sheets, besides surface features, underground contour curve lines of the chief coal-beds in the individual districts, the area worked out, and that under development of the contoured bed, all gangways, tunnels, adits, overlying and underlying the contoured bed, represented by a conventional color and line for each bed; so that the maps will give the areas worked out and undeveloped, the structure and positions of the beds, the amount of coal, and the probable structure of the undeveloped areas.

8. *Land-plants in the Middle Silurian of North Wales.*—Dr. Henry Hicks describes (Proc. Geol. Soc., May 25, 1881), remains of Lycopodiaceous plants referred by him to Dawson's genus *Psilophyton*, spherical bodies resembling the *Pachytheca* of Sir J. D. Hooker, and numerous minute bodies supposed to be microspores of Lycopodiaceæ, besides seaweeds, from the Denbighshire grits, near Corwen, in North Wales. The associated graptolites were, according to Mr. Hopkinson, partly Middle and partly Upper Silurian forms, some being Llandovery species, here dying out, and others, Wenlock species, first appearing here.

9. *Vertebrata of the Permian Formation of Texas*, by E. D. Cope.—No. 32 of Prof. Cope's Paleontological Bulletin contains Plates I to IV of remains of *Eryops megacephalus*, V, of *Empedias molaris*, and VI of *Dimetrodon incisivus*, which are published also in the Proceedings of the American Philosophical Society, vol. xix, p. 56 (see this Journal, xxi, 407). In the American Naturalist for February last he has published a list of the Fishes, Batrachians and Reptiles of the Permian of the United States, numbering in all 51 species.

10. *Life-History of Spirifer lævis*, by Prof. Henry S. Williams, Ph.D.—Prof. Williams's paper on Spirifer lævis, an abstract of which is given in the twentieth volume (1880) of this Journal, has been published in full in the Annals of the New York Academy of Sciences, vol. ii, No. 6.

11. *Geological Society of London.*—At the annual meeting of the Geological Society in February, the Wollaston gold medal was presented to Prof. P. Martin Duncan; the Murchison medal to Prof. Archibald Geikie; the Lyell medal to Dr. J. W. Dawson, of Montreal; the Bigsby medal, to Prof. Morris.

12. *On the Optical Characters and Crystalline System of some important Minerals.*—The results obtained by the more exact methods of investigation employed in mineralogy in the past few years have led to the change of a considerable number of minerals to systems of a lower grade of symmetry than those to which they had previously been assigned. The classical memoir of Mallard (Ann. des Mines, vol. x, 1876) has had a strong influence in this direction. In it he sustained this change for some of the best known species and those which had been accepted as types

of the systems to which they were referred; for example, garnet, vesuvianite, fluorite, apophyllite, zirkon, apatite, beryl, tourmaline, and so on. Mallard suggested, in explanation of cases like those named, the hypothesis that such crystals were to be considered as twins or compound crystals so made up as to have a pseudo-symmetry corresponding to a higher grade than that belonging to the individuals themselves.

The question as to the sharpness of the line dividing the crystalline systems from each other, and in many cases as to which system a given species really belongs, cannot be said to be decided at the present time. It is certainly possible to exaggerate the "optical anomalies" and to attribute to them a morphological significance when they are in fact due simply to accidental causes, such as the internal tension produced at the time the crystal was formed. For example, the species boracite, long held as a typical hemihedral form in the isometric system, although with an anomalous optical character variously explained, has by Mallard and others been referred to the orthorhombic system. Recently, however, Klein (Jahrb. Min., 1881, 239) has shown by the effect upon the optical character produced by heating sections of the crystals that the peculiarities are probably due to internal tension simply, and that there is nothing which really conflicts with its being referred to the isometric system. Similarly, analcite, the common form of which was long held to be a typical example of an isometric trapezohedron, was afterward referred to other systems by Schrauf, Mallard, Lasaulx and others, and finally referred back to the isometric system by several mineralogists who have reached the same result by somewhat different methods. Other similar examples might be given.

M. Bertrand, working from the standpoint of M. Mallard, has recently published some interesting contributions to this subject. He shows that the apparently isometric octahedrons of ralstonite exhibit two optic axes with an angle of about 90°. He has also examined a series of minerals ranging from the pure lead phosphate, pyromorphite, to the lead arsenate, mimetite; the conclusion is that while the first is truly hexagonal and has one negative optic axis, the other is really orthorhombic, and owes its apparent hexagonal form to twinning. A section of mimetite from Johanngeorgenstadt, cut normal to the vertical axis, was seen in polarized light to be made up of six triangles, each having as a base the side of the hexagon; the two optic axes make an angle of 64° in air. Between the two extremes there are various intermediate compounds containing both P_2O_5 and As_2O_5, and it is found that as the proportion of As_2O_5 diminishes, the angle of the optic axes also diminishes. Similar results have been obtained by M. Jannettaz. These facts recall the results obtained by Cooke with crystals of iodide of antimony, who proved the existence of a uniaxial (hexagonal) and a biaxial (orthorhombic) variety, of which the latter changes into the former on a slight elevation of temperature. M. Bertrand has also studied

several varieties of garnet and arrived at results essentially the same as those of M. Mallard. Sections of crystals of aplome, ouvarovite and topazolite show two optic axes with an angle of about 90°. The ouvarovite is regarded as made up of twelve pyramids having the faces of the crystal as their base and their vertices at the center. The dodecahedrons of aplome and topazolite are explained as formed of forty-eight simple crystals. Further than this, he found it possible to separate the dodecahedrons mechanically into these forty-eight individuals, each one of which is truly biaxial; the fracture-surfaces are smooth and make angles of 60° with the rhombic faces when the plane of separation obtained is parallel to the side of the rhomb, and of 90° when it is parallel to one of the diagonals. The former fractures are obtained more readily than the second, and it is concluded from this that the union of the four crystals which form together the same rhombic face is more intimate than that of the twelve complex rhombohedral pyramids among themselves. That this is the true explanation of these facts may perhaps be questioned.

13. *Brief notices of some recently described minerals.*—Chalcoménite. A new species described by M. DesCloizeaux, from the Cerro de Cacheuta, south-east of Mendoza, Argentine Republic. It occurs in transparent crystals, and in thin crystalline crusts of a blue color; it is associated with a compact mineral of a violet color, and having, according to M. Pisani, the composition (Cu_2, Pb)Se. The crystals belong to the monoclinic system and are generally combinations of the prism ($I/I = 108° 20'$), and the orthopinacoid and basal plane ($i\text{-}i/O = 90° 51'$). The plane of the optic axes is parallel, and the acute negative bisectrix perpendicular to the horizontal edge $O/i\text{-}i$. The axial angle is small, and the ordinary dispersion ($\rho < v$) so great that with a green glass the lemniscates have the form of circular rings with a black cross, while with a blue glass they become elongated ellipses, normal to the plane of polarization of the microscope, and with the hyperbolas separated about 10°, at 45° with this plane. The composition of the new mineral has not been fully determined, owing to lack of material, but preliminary trials by M. Damour show it to be essentially a hydrated selenite of copper.—*C. R.*, April 4, 1881.

Tritochorite. Described by Frenzel, locality unknown. Physical character as follows: Massive with columnar structure; cleavage longitudinal, tolerably distinct, yielding thin plates; H. = 3·5; G. = 6·25; color blackish brown, with lighter yellowish brown spots; streak pale lemon-yellow. An analysis yielded: V_2O_5 24·41, As_2O_5 3·76, PbO 53·90, CuO 7·04, ZnO 11·06 = 100·17. —*Min. Petr. Mitth.*, iii, 506.

Lautite. Also described by Frenzel, from the mine Rudolfschacht at Lauta, near Marienberg, Saxony. Occurs massive with columnar, fibrous, or granular structure. H. = 3–3·5; G. = 4·96; luster metallic; color iron-black; streak black. An analysis gave: As 42·06, S 18·00, Cu 27·66, Ag 11·74 = 99·40.

This corresponds with $Cu_3AgAs_2S_3$. Associated with native arsenic, pyrargyrite, chalcopyrite, tetrahedrite, galenite and barite. —*Ibid.*, p. 515.

SERPIERITE. M. Des Cloizeaux has given the name serpierite to a new mineral from the zinc mines of Laurium, Greece. It is found in minute dark greenish blue tabular crystals, belonging to the orthorhombic system. They have the base *O* broad, and show, also, the prism ($I \wedge I = 98° 42'$), the pyramid 1 ($O \mid 1 = 115° 32'$), and several brachydomes. The plane of the optic axes is parallel to the longer diagonal of the base; the axial angle for red glass is 44° 20′ in oil, or 67° 10′ for air. M. Bertrand has obtained similar results. According to preliminary trials by M. Damour, the mineral is a hydrous basic sulphate of copper and zinc.—*Bulletin Soc. Min. France*, iv, 89, 1881.

SCHNEEBERGITE. This mineral occurs in minute transparent octahedrons, of a honey-yellow color and vitreous to adamantine luster. H. =6·5; G. =4·1. It consists mostly of lime and antimony, with iron and traces of other elements; related to romeite. Found by Lhotsky on the Schneeberg in the Tyrol, associated with anhydrite (or gypsum), chalcopyrite and magnetite; partially described by Brezina.—*Verh. geol. Reichsanstalt*, 1880, No. 17.

"TYREEITE." One and a half hundred weight of the "carnelian marble" of Tyree, Scotland, dissolved in sixteen gallons of hydrochloric acid left as residue, thirty pounds of sahlite, a little scapolite and sphene, and some ounces of a *red mud.* By decantation 1·9 grams of powder of a deep brick red color was obtained. Of this mud, sulphuric acid dissolved ·78 grams, leaving 1·1 insoluble. The last was analyzed and decided to be an impure talc. The soluble portion yielded: Fe_2O_3 38·22, Al_2O_3 8·23, FeO 3·16, MnO 0·39, MgO 29·94, CaO 2·21, H_2O 12·47, P_2O_5 4·71, SiO_2 1·02 =100·35. To this last obviously heterogeneous substance the new name is provisionally given by Heddle; certainly no name was ever given with less reason.—*Mineralogical Magazine*, iv, 189, 1881.

FREDRICITE. A variety of tennantite, or arsenical tetrahedrite, from Fahlun, Sweden, described by H. Sjögren, peculiar in containing both lead and tin. H. = 3·5; G = 4·65; color iron-black; a brilliant metallic luster. An analysis gave: As 17·11, Sb *tr.*, S 27·18, Cu 42·23, Pb 3·34, Sn 1·41, Ag. 2·87, Fe 6·02 =100·16.—*Geol. För. Förh. Stockholm*, v, 82, 1881.

ARCTOLITE. A mineral described by Blomstrand, as collected in 1861, on "Nordskön" near Spitzbergen. It forms thin irregular plates in marble. H. = 5; G. = 3.03; colorless, or yellowish to greenish. An analysis gave: SiO_2 44·93, TiO_2 0·38, Al_2O_3 23·55, Fe_2O_3 1·24, CaO 13·28, MgO 10·30, Na_2O 1·73, K_2O 0·79, H_2O 3·54 = 99·74. It is probably to be regarded as an altered hornblende.—*Ibid.*, p. 210.

FRIGIDITE. A variety of tetrahedrite from the Valle del Frigido, Apuan Alps, described by D'Achiardi. It is usually

in compact granular masses, rarely crystallized. H. a little less than 4; G. =4·8; luster metallic; grayish-steel colored. An analysis by Dr. Funaro gave, after deducting 2·2 p. c. SiO_2 and calculating to 100: Sb 27·00, S 31·23, Cu 20·39, Fe 13·37, Ni 7·97, Ag 0·04, Zn *tr.* = 100.

DUMORTIÉRITE. Found sparingly in small crystalline grains in the gneiss of Beaunan, valley of the Azeron, south-east of Lyons. It has a bright blue color, and the specific gravity is 3·36. It has been examined chemically by M. Damour, and shown to be a silicate of aluminum, with perhaps the composition $[Al_2]_4Si_3O_{15}$; this point, however, is not entirely established. M. Bertrand finds that it has distinctive optical characters similar to those of andalusite.

14. *On the mineral Dawsonite from Tuscany.*—The rare species dawsonite, described by Dr. Harrington in 1874 as occurring sparingly near Montreal, has been found by M. Chaper at Piau Castagnaio in Tuscany and has been investigated by M. Friedel. It is found in thin plates radiated and formed of fine fibers in a quartzose rock impregnated with dolomite. An analysis gave: CO_2 29·59, Al_2O_3 35·89, Na_2O 19·13, H_2O 12·00, MgO 1·39, CaO 0·42. This corresponds closely with the results of Harrington but the material in hand seems to have been purer. This analysis agrees closely with the formula $Na_2[Al_2]C_2O_6 + 2H_2O$, which may be written $3(Na_2CO_3) + (Al_2C_3O_9) + 2(H_6[Al_2]O_6)$.—*Bull. Soc. Min. France,* iv, 28.

15. *Vanadium minerals from Cordoba, Argentine Republic.*—The occurrence of vanadium minerals at several points in the State of Cordoba has been described by Brackebusch (Las Especies Minerales de la Republica Argentina, 1879). Crystals of descloizite and vanadinite from this locality have been figured by Websky (Ber. Ak. Berlin, July and October, 1880). He shows that the vanadinite has the same hemihedral characters as apatite, the crystals being highly modified and showing the planes, *O*, *I*, *i*-2, 1, 2-2, and 3-$\frac{3}{2}$. Rammelsberg (ZS. G. Ges., xxxii, 709) has analyzed the descloizite and obtained for dark colored crystals. G. = 6·080: V_2O_5 22·74, PbO 56·48, ZnO 16·60, MnO 1·16, H_2O 2·34, Cl 0·24. This corresponds to the formula $R_4V_2O_9$ or $R_3V_2O_8 + RH_2O_2$ with R=Pb : Zn=1 : 1, and makes the species analogous in composition to olivenite and libethenite.

Occurring with the descloizite and vanadinite is a mineral in small black striated prismatic crystals, for which Dr. Döring proposes the name *Brackebuschite.* An analysis by him yielded:—V_2O_5 25·32, P_2O_5 0·18, PbO 61·00, MnO 4·77, FeO 4·65, ZnO 1·29, CuO 0·42, H_2O 2·03=99·66. For this Rammelsberg calculates the formula $R_3V_2O_8$ + aq., which (Mn : Fe=1 : 1) requires:—V_2O_5 25·45, PbO 62·09, MnO 4·95, FeO 5·01, H_2O 2·50=100.

16. *Zinn: Eine geologisch-montanistisch-historische Monografie;* von E. REYER. 248 pp. 8vo. Berlin, 1881 (G. Reimer).—Dr. Reyer has already published a series of papers devoted to the subject of tin, treated both from the geological and the technical

standpoint. In this volume he has brought together a very large amount of useful matter. The introduction contains a very complete list of memoirs previously published. The subject is divided geographically, the tin-mining districts of Bohemia and Saxony coming first, then those of Cornwall, Burma, Siam, Australia and Tasmania. The geology is treated briefly and concisely, in part in connection with each locality, and more fully in a résumé at the close. The larger part of the volume, however, is devoted to a history of the tin-mining, and here much valuable information has been brought together.

III. Botany and Zoology.

1. *Marine Algæ of New England and adjacent coast;* by W. G. Farlow, M.D. (Reprinted from Report of U. S. Fish Commission for 1879.) Washington, 1881. 8vo, pp. 210, tab. xv.—Hitherto the only good work attempting to describe all the seaweeds of our coast has been the *Nereis Boreali-Americana* of Dr. Harvey, published by the Smithsonian Institution in three quarto volumes from 1852 to 1858. This work took in the seaweeds of the entire coast of the United States, Pacific as well as Atlantic. Since it appeared the industry of collectors has detected many additional species along the several portions of our coasts, and the acumen of Phycologists at home and abroad has given us much information respecting the true structure, physiology and affinities of many of the forms already known. In the present work Professor Farlow has limited himself to the seaweeds known on or near to the coast of New England; but the systematic classification which he has adopted, and the many interesting and new points of structure and function which he has either discovered for himself, or has accepted from the writings of Thuret, Bornet, Agardh, Le Jolis, Rostafinki, etc., render the work a valuable text-book for the study of marine Algæ wherever the English language is read.

The old classification of Algæ was into the three sub-classes of *Melanospermeæ*, *Rhodospermeæ* or *Floridеæ* and *Chlorospermeæ*. Within thirty years the disposition of the *Floridеæ* has met with no fundamental change, but the *Melanospermeæ* and the *Chlorospermeæ* are no longer recognized in their integrity. The sexual reproduction of the *Fucaceæ* is now as well understood as that of *Rosaceæ*, and is clearly of an oosporic character; that is, the unfertilized nucleus is fertilized by antherozoides after exclusion from the conceptacle. But no sexual reproduction of *Laminarieæ*, *Punctarieæ*, *Dictyosiphonieæ*, *Desmarestieæ*, and their allies has been detected, and it is very doubtful whether any exists. These tribes are therefore grouped in the suborder *Phæosporeæ*, and united with *Chlorosporeæ*, *Bryopsideæ* and *Botrydieæ*, all grass-green Algæ, in the order *Zoosporeæ*.

The obscure *Chroococcaceæ* and *Nostoclineæ* form also a separate order, the *Cryptophyceæ*. Thus Professor Farlow recognizes four orders, *Cryptophyceæ*, *Zoosporeæ*, *Oosporeæ and Flori-*

deæ. An ample explanation of this system is given in the twenty-four pages of introduction, where one may look in vain for a recognition of the conjoining of Algæ and Fungi in chlorophyllose and achlorophyllose branches of common classes, as was proposed by Cohn and Sachs, and set forth in Professor Bessey's "Botany for High Schools and Colleges." It is certainly pleasant to the student of Algæ to be relieved from having to consider the objects of his study not a distinct class or group of classes, but only chlorophyll-bearing equivalent of Fungi, and so but halves of an uncomprehended and ill-assorted whole! It is still more reassuring when this relief comes from the laboratory of one so learned in the physiology of both Algæ and Fungi as Professor Farlow.

In the quarter of a century which has elapsed since the appearance of Harvey's *Nereis*, but one conspicuous red Alga has been discovered on our coast and that one is *Nemastoma Bairdii*, of which Professor Farlow found but a solitary specimen at Gay Head in 1871. The principal changes in nomenclature among the *Florideæ* are the substitution of *Rhabdonia tenera* for *Solieria chordalis*, of *Rhodophyllis Veprecula* for *Calliblepharis ciliata*, and of *Griffithsia Bornetiana* for *G. corallina*. *Rhodomela gracilis* and *R. Rochei* are reduced to forms of *R. subfusca* and *Polysiphonia formosa* to *P. urceolata*. Harvey knew certainly of no Coralline on the New England coast. But *Corallina officinalis* is very common, and Professor Farlow has recognized, in addition, five species of *Melobesia* and two of *Lithothamnion*. There are two or three added species of *Fucus*, and *F. nodosus* is excluded from the genus, to become *Ascophyllum nodosum*. *Sargassum Montagnei* is very properly retired. Among the great *Laminariæ* are some changes: *L. dermatodea* and *L. borea* together constitute *Saccorhiza dermatodea*, the genus differing from *Laminaria* principally in the form of the hold-fast and in the presence of cryptostomata. *L. platymeris* is added, *L. saccharina* and *L. digitata* retained, though with some apparent hesitation, *L. longicruris* fully recognized, and *L. Fascia* referred to the genus *Phyllitis* in *Scytoriphonieæ*.

There are several changes among the filamentous *Chlorosporeæ*, and still more that is new (to Americans at least) among the membranous forms, the genus *Monostroma*, with four species, being introduced, and the species of Ulva arranged after Le Jolis in the "Liste des Algues Marines de Cherbourg." The *Cryptophyceæ* were but indistinctly known to Dr. Harvey, but are now satisfactorily arranged in sixteen genera, among which only *Oscillaria*, *Microcoleus*, *Lyngbya*, *Calothrix* and *Rivularia* are given in the Nereis.

The Diatoms and Desmids are not treated of in this work.

The fifteen plates at the end of the volume are mainly illustrative of the different kinds of fructification seen in Algæ, and add much to the ease with which one may comprehend the principles of classification here set forth.

It is to be hoped that the able botanist who has given us this most important contribution to the history of North American

Algæ will before long publish a similar report on the seaweeds of the Pacific Coast, and then a comprehensive work on all North American Marine Algæ. D. C. EATON.

2. *Das System der Medusen von E. Hœckel; Zweite hälfte.*— The conclusion of the first part of "Hæckel's System der Medusen," devoted to the Acraspedæ, Steganophthalmæ, or the Discophoræ in their widest sense, has been issued.

Though some of the orders adopted by Hæckel differ but slightly from those previously recognized, they are invariably baptized anew, and we find in this, as in all the systematic work of Hæckel, a deliberate disregard of the nomenclature adopted by his predecessors. Hæckel stretches the laws of nomenclature to their extreme limits, and nothing can render them more ridiculous than such a systematic nomenclature as that of the System d. Medusen. Every genus, every family, every order, in fact, every division or subdivision adopted, invariably receives a new name if its limits are either greater or smaller than those of the corresponding division previously known to science. The same principle would warrant us in rebaptizing any well-known animal, provided some important point of its structure, unnoticed heretofore, were described in detail and made to form the basis of the new-fangled name by which it is hereafter to be known. Nomenclature is properly an aid in ascertaining the views of our predecessors, and in limiting and in defining the existing state of the knowledge of a group; its main object is not the introduction of new terms, and an endless confusion, merely in order to glorify the peculiar systematic views of the latest philosophical writer on the subject. This defect to which we had already called attention in the first part of the System is far more prominent in the second part, where the material is less complete, and is derived, for the greater part, from alcoholic specimens of Medusæ which Hæckel has had no opportunity to study from life. We may close this part of the subject by asking Medusologists what is gained by the fabrication of such names as Stauromedusæ and Cubomedusæ?

Hæckel adopts, with Huxley and nearly all the later writers on Medusæ, the group of Lucernaridæ, and one of his most interesting new types is the genus Tessera (from specimens collected by the Challenger). This genus shows the close systematic affinity existing between the Lucernaridæ proper and the true Discophoræ. It is, in fact, nothing but a free Lucernaria. Closely allied to them are the Peromedusæ. To this group belong a number of large Medusæ, which probably live on the bottom in deep water. Several species were collected by the "Challenger," and the "Blake"* dredged off the N. E. extremity of George's Bank a number of specimens of Dodecabostricha (Brandt), Periphylla (Steenst.).

Hæckel establishes (from alcoholic specimens) several genera and families of this interesting group of Medusæ, and gives an

*See Bull. M. C. Z., vol. viii, No. 9, 1881.

excellent anatomy of their more prominent details, hitherto only known from the drawings of Mertens and the descriptions of Steenstrup. It seems to us as if Hæckel had needlessly multiplied not only the families, but even the genera of this group. (Compare Pericolpa and Periphylla.)

Among the Charybdeidæ we must call special attention to the interesting genera Procharybdis and Chirodropus. These are specially important as bringing the Charybdeidæ into closer systematic relationship to the other Discophoræ.

In the next order, the Disco-Medusæ, he adopts the primary subdivisions of the group Semeastomæ and Rhizostomæ proposed by Agassiz. Although he prefaces his review of that classification by stating that it is entirely unnatural, he at once, after removing some of the forms included in these divisions into other families, proceeds to adopt it. Hæckel makes a most characteristic attempt to show that Agassiz willfully neglected to quote Huxley's paper on the anatomy and affinity of the family of the Medusæ. (See p. 27 Contrib. Nat. Hist. U. S., vol. iii, where Huxley's paper is quoted.) Naturalists who willfully ignore or misrepresent the work of their colleagues are fortunately more rare than those who are known to manufacture drawings to suit their pet theories. Hæckel, of course, differs from Agassiz radically in his estimate of the value of the homology between Acalephs and Echinoderms. His view may be "grundfalsch" according to Hæckel, but it certainly is not yet so considered by those embryologists who have the best right to an opinion on the subject.

The first subdivision adopted by Hæckel (in addition to those mentioned above), the Cannostomæ, can hardly be considered creditable to a zoologist having so extensive a knowledge of Acalephs as Hæckel. This subdivision is based entirely upon a few alcoholic specimens of Discophoræ, any one of which may turn out to be the young stage of some unknown Discophoræ. Of the Cannostomæ, Hæckel has examined only two species from living specimens; the other sixteen are based upon alcoholic material, which, no matter how well preserved, will not give even a Hæckel an idea of their ontogeny. Among the Semeastomæ we find the new family of Flosculidæ, including Floscula and Floresca—genera which are probably closely allied to embryonic Pelagiæ and the new family of Ulmaridæ: the genera Ulmaris, Umbrosa and Undosa, allied to embryonic Aureliadæ.

Among the Rhizostomidæ Hæckel gives, with other new genera, good figures of Archirhiza and of the family of Versuridæ (Versura, Cannorhiza). Among the Crambessidæ, a family which Hæckel established in 1869 upon a new species of Rhizostoma, are illustrations of Leptobrachia and Thysanostoma. This same species of Crambessa (*C. Taji*) subsequently formed the subject of an excellent monograph by Grenacher and Noll, which added greatly to our knowledge of the Rhizostomæ.

The majority of the plates of the second part of Hæckel's

Acalephs are drawn from the alcoholic material which was placed at his disposal by nearly all the European museums. These illustrations suffer as compared with those of the Hydroids, where Hæckel had a large amount of new, fresh material at his disposal.

The value of this monograph is, however, very great, as it has cleared the ground of a great deal of rubbish and will enable the future investigator to work upon a comparatively firm basis.

Discophorous Medusæ are by no means as common as Hydroids; their habits are as yet but little known; though they are often found in swarms upon the ocean, it is usually under circumstances which render their capture or detailed examinations at the time impossible. I well remember laying off the Bar of San Francisco for a number of days and seeing the greater number of the species of Discophoræ, so well figured by Mertens, float by out of reach, only near enough to be roughly identified, while it was impossible, on account of the rolling of the schooner, to examine properly the few I was fortunate enough to capture. Fortunately, as Hæckel's monograph has well shown, a great part of their structure can be made out from carefully preserved alcoholic specimens, and until some naturalist, under more favorable circumstances, gives us anatomical details drawn from life, to these we must look for the principal additions to our knowledge of the Discophoræ.

A list of the fossil Medusæ thus far described is added to the volume, and a few appendices, making corrections and additions of imperfectly known Medusæ. It closes with a final appendix containing a puerile attack on Metschnikoff, evidently suggested, as Hæckel naively says, by the fact that "Metschnikoff bei jeder Gelegenheit meine zoologische Arbeiten auf das heftigste schmäht und angreift," and that Metschnikoff insists, with other Russian naturalists, in writing in his own language. It certainly is a pity that Russian naturalists will not follow the example of the Scandinavians and give us French or English résumés of their memoirs. But no nation, least of all the German, has a right to ask the most active embryologists of the present day to write to suit their convenience. The day may yet come, in spite of Hæckel, who evidently does not appreciate Chinese and Japanese civilization, when their investigators also will have as good a right to be heard as the Russians by all except the close corporation of naturalists of whose claims Hæckel is the exponent.

A. AG.

3. *New and little known Reptiles and Fishes in the Collections of the Museum of Comparative Zoology;* by S. GARMAN. Bull. Mus. Comp. Zool., vol. viii, No. 3. pp. 85–94. Cambridge, 1881.

4. *On the Results of Dredging under the supervision of Alexander Agassiz along the Atlantic Coast of the United States during the Summer of* 1880 *by the Steamer Blake.* Report on the Cephalopods, and on some additional species dredged by the U. S. Fish Commission Steamer Fish Hawk in 1880, by A. E. VERRILL. Ibid., vol. viii, pp. 95–230. Also, Report on the Selachians, by S. GARMAN. Ibid., pp. 231–284.

5. *Arrangement of the Perissodactyles, with a note on the Structure of the foot of Toxodon*, by E. D. COPE.—Proceedings of the American Philosophical Society, April 15, 1881.

IV. ASTRONOMY.

1. *Photographic Spectrum of Comet* 1881, *b;* by WM. HUGGINS. —On Friday night (June 24th), I obtained with one hour's exposure a photograph on a gelatine plate of the more refrangible part of the spectrum of the comet which is now visible. This photograph shows a pair of bright lines a little way beyond H in the ultra violet region, which appear to belong to the spectrum of carbon (in some form) which I observed in the visible region of the spectra of telescopic comets in 1866 and 1868. There is also in the photograph a continuous spectrum in which the Fraunhofer lines can be seen. These show that this part of the comet's light was reflected solar light.

This photographic evidence supports the results I obtained in 1868, showing that comets shine partly by reflected solar light, and partly by their own light, the spectrum of which indicates the presence in the comet of carbon, possibly in combination with hydrogen.—*Communication from the Author; also Nature*, June 30.

2. *Notice of the Comet;* by CHARLES E. BURTON.—At about 11h. 0m. G.M.T. on June 29, a transit of the "following" nuclear jet of the great comet over a star of 8m. was observed by Mr. N. E. Green, of 39 Circus Road, St. John's Wood, and by me, with a 12½-inch reflector belonging to Mr. Green. Definition was very good and tranquil. As the star became involved in the jet it gradually increased in size, and, when seen through the brightest part of the jet traversed, resembled an ill-defined planetary disk about 3″ in diameter. At this moment the comet seemed to have two nuclei similar in aspect and brightness.

The effect of the cometary matter on the star's image resembled that of ground glass, not that of fog; the image of the star, being dilated into a patch of nearly uniform brightness, instead of presenting a sharp central point with a surrounding halo. Cirro-stratus, passing into rain-cloud, produces on the appearance of the sun an effect the counterpart of that produced by the cometary emitted matter on the star. There was not sufficient light for the use of the spectroscope, the star, afterwards identified as B.D. +65°, 519, being fainter than 8m.

The transit of the jet occupied about 3m. and the star slowly resumed its ordinary appearance and dimensions, the image *contracting* as the center of the jet left the star behind. A transit of this kind has not frequently been observed, at least under such favorable conditions as to brightness and definition of the objects, and it is to be hoped that others may have been as fortunate as Mr. Green and the undersigned.

If the point, which obeys the Newtonian law, be a solid body, the observation just recorded seems to show that its true outline

would probably be rendered unrecognizable, and its aspect totally altered by the (refractive?) power of the coma and jets.—*Nature*, July 7.

3. *Observation on the Comet;* by W. H. M. CHRISTIE, made at the Royal Observatory, Greenwich.—Further measures have been obtained at Greenwich of the position of the least refrangible edge for three of the four comet-bands with the following results:—

	Yellow band.	Green band.	Blue band.
Comet	5630·4 ± 1·6	5162·7 ± 0·4	4733·9 ± 1·1
Bunsen Flame	5633·0	5164·0	4736·0
No. of Obs.	7	26	6

The identity of the comet-bands with those in the first spectrum of carbon appears to be clearly established, but in each case the comet-band is slightly shifted toward the blue. The displacement of the green band, if real, would indicate an approach of 47±14 miles per second, whereas the comet was actually receding from the earth at the rate of about twenty miles per second. Such a displacement might, of course, be explained by an emission of cometary matter on the side toward the earth, but it would seem more probable that it is due to the circumstance that the edge of the comet-band is not quite sharp, and that a small portion on the red side is cut off. This would apply with still more force to the yellow and blue bands, which indicate somewhat larger displacements toward the blue. The displacements however, though all in the same direction, are not largely in excess of the probable errors. The comet-bands were compared with those given by vacuum-tubes containing cyanogen and marsh-gas, as well as with those of the Bunsen-burner flame, and three forms of spectroscope were used, viz: (1) the half-prism spectroscope with a dispersion of 18½° from A to H, and a magnifying power of 14; (2) the half-prism spectroscope reversed (as for prominence observations), giving a dispersion of 5° from A to H and great purity of spectrum, with a magnifying power of 28; and (3) the star spectroscope with a single prism of flint. No measures were obtained of the band in the violet, which was only seen on two occasions. It appeared to be sensibly coincident with the band in the first spectrum of carbon at 4311.—*Nature*, July 14.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *International Polar Stations occupied by the Signal Service.*—The head of the U. S. Signal Service, General Hazen, has issued circulars from which are taken the following facts.

The permanent station will be established at the most suitable point near Point Barrow, Alaska (71° 27′ N., 156° 15′ W., as determined by Beechey). Meteorological, magnetic, tidal, pendulum and other observations of a physical kind are to be made and also collections gathered, as complete as possible, in mineralogy, botany, zoology and ethnology. This station will be visited in 1882, 1883, and 1884 by a steamer or sailing vessel, to furnish supplies and such additions to the party as may be necessary.

The officers assigned to duty as the expeditionary force are Lieut. P. HENRY RAY, of the 8th Infantry, Acting Signal Officer, and Commander of the Expedition; G. S. OLDMIXON, U. S. Army, Acting Assistant Surgeon; Sergeants J. MURDOCH, U. S. A., and MIDDLETON SMITH, U. S. A., Naturalists and Observers; Capt. E. P. HERENDEEN, Interpreter, Storekeeper, etc.; Mr. A. C. DARK (of the Coast Survey), Astronomer and Magnetic Observer.

The meteorological and tidal observations will be made at exact hours of Washington civil time—the longitude of the Washington Observatory being $5^h\ 8^m\ 12^s{\cdot}09$ west of Greenwich; and the regular magnetic observations at even hours and minutes of Göttingen mean time—Göttingen being in $0^h\ 39^m\ 46^s{\cdot}24$ east of Greenwich, or $5^h\ 47^m\ 58^s{\cdot}33$ east of Washington. The equipment in instruments for the various kinds of physical observations is to be very complete.

2. *Annual Report of the Board of Regents of the Smithsonian Institution, for the year* 1879. 632 pp. 8vo. Washington, 1880.—The Smithsonian Institution is ably fulfilling its purposes under Professor Baird, in the various ways established during the administration of Professor Henry. This Report gives an account of what it is doing in the way of aiding and extending research, and explorations, making collections and sustaining the National Museum, carrying forward the objects of the Fish Commission, making exchanges in specimens, transporting exchanges in publications between this and foreign countries and by various other methods. Pages 143 to 212 are occupied with a memoir on James Smithson and his bequest. Next follows the General Appendix containing many Archæological and Ethnographic papers, occupying 270 pages, and also, Reports of American Observatories by Prof. E. S. Holden, and translations of a memoir by Dr. F. J. Pisko on the present fundamental principles of Physics, and another by E. H. Von Baumhauer, Permanent Secretary of the Netherland Society of Sciences, Harlem, on a Universal Meteorograph designed for detached Observatories.

3. *Endowment of the American Chemical Society.*—An effort is now on foot, and vigorously pushed, to secure an endowment for the maintenance of the American Chemical Society. The sum proposed to be raised is fifteen thousand dollars, and a list published in the Philadelphia Inquirer, July 6th, shows that about one-half this sum has already been subscribed. Professor ALBERT R. LEEDS of Hoboken is Chairman of the Endowment Fund Committee, and receives notices of subscriptions. This laudable effort will, when complete, place the publication of the Journal of the Society upon a safe basis. The chemical manufacturers of the United States are a wealthy body, and we notice with pleasure that some of them have responded liberally to this call, as indeed they can well afford to do. There are but few men of wealth among the chemical investigators, but the names of several of the leading chemical teachers are recorded as subscribers to this fund; and aid from others is invited.

4. *Dr. J. Lawrence Smith's Collection of Minerals and Meteorites.*—We learn from the correspondence published in the Louisville Courier-Journal of July 12th, that Dr. Smith has presented his minerals and meteorites to the "Polytechnic Society" of Louisville, Kentucky. This society already possessed the well known mineralogical collection formed by the late Dr. Troost of Nashville University. The collection of meteorites formed by Dr. Troost, and for the most part described by him, was separately secured by Dr. Smith, and he had added largely to it by his own researches and exchanges. The collection thus increased now returns, as we understand, to the Troost cabinet.

Dr. Smith's gift to the "Polytechnic" includes also a collection of physical apparatus, which will now be in the custody of Dr. Tobin, who is entirely devoted to its preservation and scientific usefulness.

OBITUARY.

ACHILLE DELESSE.—The death of Delesse is mentioned on page 416 of the May number of this Journal. Delesse's researches in science were chiefly in the departments of mineralogy and geology. His labored memoirs on metamorphism and pseudomorphism, and his investigations with regard to the chemical constitution and other characters of various kinds of rocks, contributed largely to the progress of lithology and geology. He experimented also with important results on the expansion of rocks by heat and fusion, the magnetic properties of rocks, their absorption of moisture and its effects on their resistance to crushing, and on other points. In connection with the results of the Exposition at Paris of 1855, he produced a very valuable work entitled "*Matériaux de Construction;*" and he later published memoirs illustrated by large charts, on the constitution of the bottom of the seas, and on the soils, underground water-plain, and subsoils, about Paris. His "Revue des Progrés de la Géologie," prepared for the "Annales des Mines," but lately with the aid of M. de Lapparent, reached its sixteenth volume during the past year. Delesse, in 1845, was placed in the chair of Mineralogy and Geology at Besançon, and in 1850, in that of Geology, at the Sorbonne, at which time he was made "Ingénieur des Mines," and had charge of the quarries of Paris. Eighteen years later he was made Professor of Agriculture at the École des Mines. In 1878, he was promoted to Inspector-General of Mines, and placed in charge of the southeast division of France. Delesse was elected a member of the Academy of Sciences in 1879. M. Daubrée closes as follows his remarks at the funeral, on the 29th of March: "The breadth of mind and uprightness of Delesse, his astonishing powers of work, his learning, his kindness of heart, associated with true modesty and great loyalty of character, have made him esteemed and beloved during all periods of his useful career."

ETIENNE HENRY SAINTE CLAIRE DEVILLE, the eminent French Chemist, died at Boulogne-sur-Seine, on the 1st of July, having passed his 63d birthday in March last.